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ELECTROGRAPHY; OR THE NEW PHOTOGRAPHY.

By J. W. Gifford.

THE extreme interest taken by the public in this subject, and the difficulty of obtaining reliable information about it, must be my excuse for venturing to write of what is still so little understood. Most of those engaged in experiment are too busy, and too eager to try for new effects, to care to spend their time in writing. When the news of Prof. Röntgen's wonderful application of this form of electric force first reached this country, it was received with doubt by some and with scorn by others. Now we believe and have seen what would have seemed too absurd for a work of fiction a few years ago. Not only can coins enclosed in a box, or laid under a pie-dish, be electrographed with perfect ease, but bones enclosed in living flesh can be shown with little more difficulty. Any imperfection in the bones, any foreign body in the flesh, is made as clearly visible as though laid bare by the surgeon's knife. Hitherto, this can only be said to have been done to perfection in the case of the hand or foot, but when we remember that the first news of Prof. Röntgen's experiments reached us but a few weeks ago, the only marvel is that so much has already been accomplished.

The earliest experimenters in England who attained satisfactory results by the new influence—call it what you will—were Mr. A. A. Swinton, in London, and myself at Chard.

Shortly before the article appeared in the *Standard* last January announcing Prof. Röntgen's discovery, I had been experimenting with spectrum photography, and for this purpose had bought a hand dynamo and a large spark coil, so as to volatilize the more refractory elements. Some fifteen years ago, when Prof. Crookes' researches on radiant matter were first published, I had bought a set of Crookes tubes, and therefore found myself equipped, by good fortune, with all the necessary material for making the experiments. But so imbued was I with the idea of spectrum analysis and spectrum photography, the study of which had engaged my attention for years, that no explanation of the discovery other than a photographic one occurred to me. I therefore tried a set of experiments—all of which failed—taking as my standpoint the idea that the photographs must be produced by ultra-violet rays. Thinking the thing was a hoax, or at any rate a misconception, and seeing that the experiments in Vienna had, up to that time, failed, I sent a communication to the Royal Photographic Society, detailing my experiments and their failure. This arrived just too late for the meeting on the 14th of January.

After that the papers became more definite, and I tried again, this time abandoning the theory of light for that of electricity; and on Saturday the 18th, to my great delight, I succeeded in electrographing a child's hand through cardboard. This was shown at the Photographic Meeting on the following Tuesday. In this early experiment, and in fact in all the earlier ones, the plate was enclosed in a cardboard box, such as photographic plates are packed in, and the hand laid on the lid of the box about two inches below the glass bulb—for, as far as appearance goes, tube is a misnomer—with the result that a child's hand appeared on the plate after development. In the earlier attempts five minutes' exposure was given, and in the first successful one the nails appeared, but little or no bone. Never since the first experiment have the nails appeared—why is not known. Probably the bones did not appear partly because it was a child's hand and the ossification imperfect, and partly because the exposure was too short for the power used. Later experiments have shown better results, and for the benefit of those who have never seen the apparatus at work I will describe what is used.

First there is a hand dynamo, giving a current of ten volts, fifteen ampères; then a spark or intensity coil, giving a ten-inch spark; and lastly the glass bulb, which is exhausted to about the millionth of an atmosphere. Of course every man has his own fad, but I believe all the most successful experimenters have used apparatus similar to this. The different parts of the apparatus are connected, the circuit closed, and the dynamo revolved. The bulb is filled with a beautiful green light, which looks a very yellowish green by daylight—a colour difficult to describe, but characteristic of this state of exhaustion. Tubes less exhausted show a whitish or violet light, and more exhausted they do not allow the spark to pass freely enough to do the work. The greenish light is, as far as my experience goes, a *sine quâ non*. The tube in the later experiments has been placed about eight inches from the object to be photographed, and this, though it lengthens exposure, vastly improves definition.

One must leave off thinking of these pictures as photographs, and think of them and reason about them as shadows. If a match be lighted and the blade of a knife be held up between it and the wall, definition improves and the size of the shadow decreases as the knife is farther from the match and closer to the wall. This simple

experiment—which the reader should try—shows why some of the earliest hands appeared so large and had such "woolly" or indistinct outlines.

The subject to be operated on is taken into the dark room. A sheet of celluloid or mica is laid over the film of a sensitive plate; the hand, if that is to be the part electrographed, is laid on the celluloid, and the whole enclosed in a black cloth bag, tied tightly round the wrist, so that no light may get at the plate. The plate may then be taken into broad daylight—not bright sunshine—and laid, with the patient's hand upon it, on a table over which the bulb is hung. I use a small wooden stand, of the size of a whole plate, with a ledge on one side to prevent slipping, attached to one end of which is a glass rod in the form of an inverted L, from the horizontal arm of which the tube hangs. In some experiments no celluloid was used, and in more than one case the warm moisture of the hand partially melted the gelatine. In others a paper bag made of grocer's paper was slipped over the plate to prevent contact. The paper meant is the greased paper used for wrapping up butter, and this is supposed to be quite waterproof; but in some cases the grease melted, and the last state of that plate was worse than the first. With a cool hand paper is better, for it is less slippery; but with a hot one mica or celluloid is best. Both the latter are so transparent to the rays which do the work that a mica disc and a piece of celluloid laid on a plate and electrographed are barely visible in the negative. The exposure varies according to the thickness of bone and tissue to be penetrated, and according to the moisture in the air. No pain is felt beyond a slight cramp, or "pins and needles," owing to the limb being kept in one position so long. After exposure the plate is developed and fixed as in ordinary photography.

Among the subjects hitherto electrographed with my apparatus are, of course, a large number and variety of hands, some well- and some ill-formed. This is the easiest living subject. Several feet have been taken, some elbow joints, a club-foot, living cats' and dogs' paws, a flatfish, a rabbit's shoulder (dead) showing a shot jammed between the small bones, and a boy's forearm with several shot embedded just below the elbow. The accompanying prints of a sparrow (Fig. 1 and Fig. 2) illustrate one of the peculiarities of electrography. The two prints are from the same bird, one photographed in the ordinary way, and one electrographed. The first shows no peculiarity, but the second looks like a half-hatched chick. Although it was known that feathers were transparent to the new rays, the result at first seemed startling. The sparrow, when dead, was laid flat so as to show the ventral aspect. Some confusion of image is caused by the bones of the back appearing through those of the front. The merrythought is plainly visible and the breast-bone. The round black thing is supposed to be the gizzard. This print is important on account of its indications of internal organs, which have, so far as I know, never before (February 29th) been electrographed inside an entire animal. The illustrations of a mouse show internal organs still more clearly. The first one (Fig. 3) is the ventral aspect. It shows the attachment of the hind legs and the vertebræ of the tail especially well. It also seems to show signs of lungs, liver, and kidneys. The second one (Fig. 4), in profile, shows the dental formation of the rodent, and, still more clearly, the internal organs. As the mouse in this case was laid on its side, the legs furthest from the plate are, of course, indistinct. No others of my negatives differentiate so well between the different structures, and, in most of them, only the difference between bone and flesh has been visible.

The child's hand and forearm (Fig. 6) illustrates the incomplete ossification proper to the age. As it was a child of six, it was difficult to keep the hand perfectly still for ten minutes, and the outline is, therefore, somewhat indistinct. The "growing places" between the phalanges of the little finger are well shown. Here the bone is still in a cartilaginous state.

The adder (Fig. 5) was laid on its back and pressed well on to the plate, but being somewhat crushed with packing, and having stiffened after death, it did not touch quite evenly. Hence a little indistinctness here and there. The head is remarkably well defined, every bone being distinct, and the fangs appear clearly.

For a hand from ten to fifteen minutes gives good results, for a foot from thirty to fifty, and for an elbow about the same. The cat objected at the end of four minutes, and the dog at the end of seven. The cat's paw, though a thin negative, was quite clear; but the dog had evidently twitched a little. In these cases the paws were fastened to the plate with two elastic bands, and the paw held well out from the body of the animal. The paw was tightly gripped, and the bag tied round the wrist of the holder above the animal's shoulder, so that both paw and hand were inside the bag. Something of this sort would be necessary in any attempt to electrograph a baby's limb. No fur is shown in any of the negatives. A foot can, of course, be electrographed through a stocking; but the edges of the stocking show, and the definition is slightly impaired. The elbow joint and the club-foot, being thick, did not give good definition, for the further from the plate the more "woolly" the outline. The flatfish was a small dab, and had, unfortunately, been cleaned, so that the viscera are not there; but the bones show through the flesh and skin as clearly as though it was made of glass. In many of the hands and feet the bones show clearly down to the wrist and ankle. In one case, the back of a lady's hand, which had a long exposure, the bones of the wrist look as though they were cut out in stone, they are so distinct; and the ankle bones in one foot are no less clear.

In the case of an invalid it will probably be impossible to get such fine definition, for only one or two of the subjects tried have proved such good sitters as the lady mentioned above. Invalids are usually nervous and inclined to twitch, or they have hot, moist hands or feet, or their malformation renders it difficult, as in the club-foot, to lay the part well on the plate. For taking a foot, a chair placed on a table is used; but for the club-foot, as the side of the foot was to be taken, a table, with a mattress on which the patient lay, was employed, and the leg strapped to the table. The part of the limb electrographed is not the part next to the tube, but that next to the plate. This is obvious if one remembers that it is a shadow. Thus, the hands are all palms and the feet are all soles unless special arrangements are made. The distinction between bone and flesh is very marked, but I have never seen any sign of a nerve or blood-vessel. If these were ever visible, one would have expected to see them in the forearm with the shot, or in one of the elbow joints, which have been taken in various positions, and in which part of the body the vessels must be large enough to show.

As regards the tube, I used at first a Crookes tube, which I had bought more than fourteen years ago. With this I make almost continuous exposures, stopping every five or ten minutes to feel the terminals of my tube, and unless they are hot, which is seldom the case, I go on again at once. My tubes are much larger than those now sold in England. I used only two for all my early experiments. The first one seemed to be deteriorating; it became increasingly difficult to get the spark through, so I tried another. That gave splendid results for about a fortnight, and then began

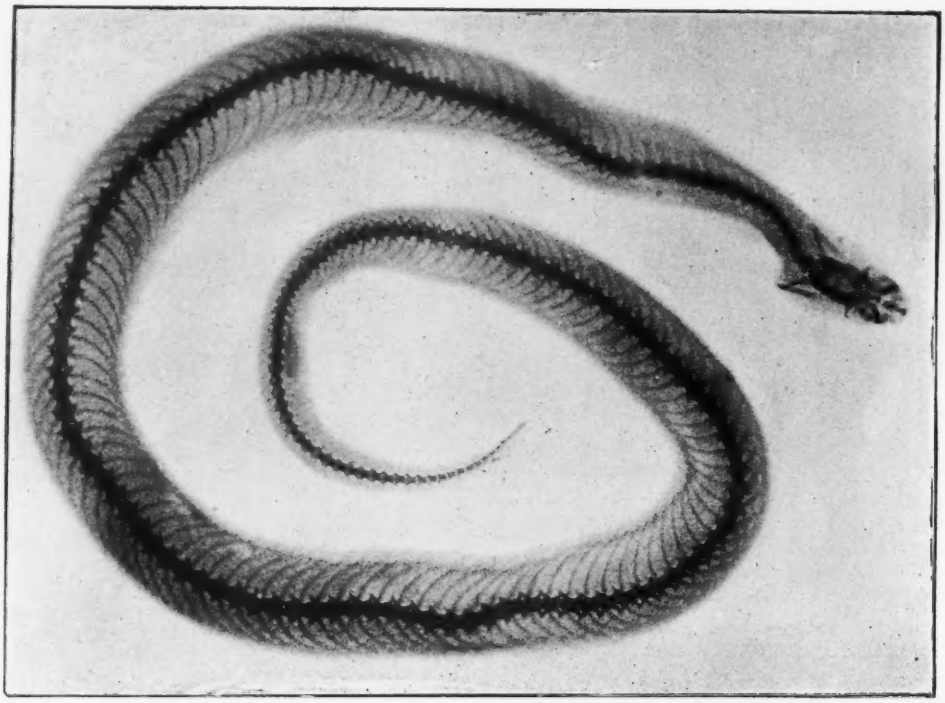

FIG. 5.—Dorsal view of Adder. Electrographed by Mrs. Gifford and Miss Baylis, with a tube by Mr. A. C. Cossor. Exposure, ten minutes. (March 5th, 1896.)

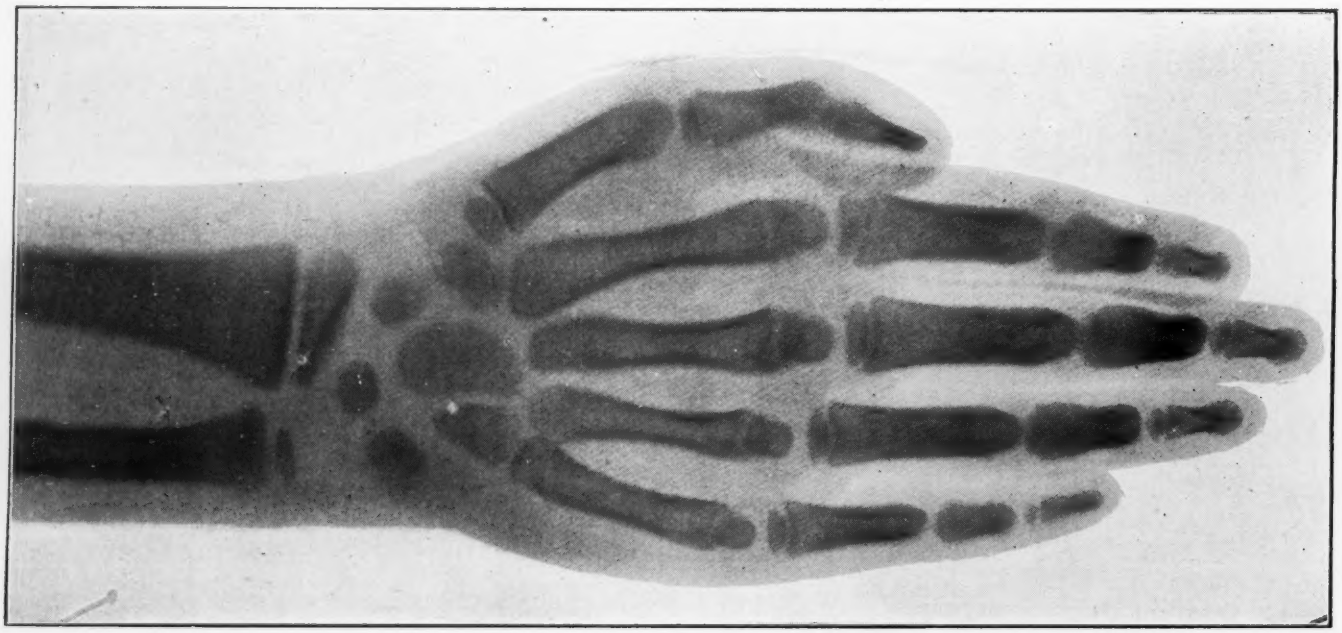

FIG. 6.—Hand and Forearm of Sylvia Gifford, aged 6, showing incomplete ossification. Electrographed by Mr. J. W. Gifford. Tube by Mr. C. Baker. Exposure, one minute. (March 14th, 1896.)

FIG. 1.—Ordinary Photograph of a Sparrow. By Mr. F. Higgins, Photographer, Chard.

FIG. 2.—The same, electrographed by Mr. Gifford and Miss Baylis, showing bones and internal organs, but no feathers. Exposure, three and a half minutes. (February 25th, 1896.)

FIG. 3.—Mouse, ventral aspect. Electrographed by Mrs. Gifford. Exposure, five minutes. (February 28th, 1896.)

FIG. 4.—Mouse in profile. Electrographed by Mrs. Gifford. Exposure, five minutes. (February 28th, 1896.)

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to act badly, the spark illuminating the tube fitfully. Then I reinstated the first one, and found it had renewed its youth and worked as well as ever. Of course, until it can be shown that the second improves with rest, one cannot consider the point to be proved: it may be merely that experiment has improved other conditions; but for those who have already spoiled their tubes, even the possibility is cheering.

It is exceedingly difficult to get a tube that will act. Of the first five tubes of English make that I tried, none gave good results. One cracked on being taken out of the box—with no blow, but merely on exposure to the air of the room. Another showed a white and violet light which gave very little effect after very long exposures. A third broke down at the first spark, owing to the air occluded in the terminals being driven into the bulb and spoiling the vacuum. The fourth and fifth are still intact, but appear to require exposures of far greater length than any mentioned above. They are all much smaller than the old Crookes tube, so I tried them with a small coil; but though they looked very pretty, they did little or no work. It has been suggested that an aluminium window let into the side of a tube would shorten exposure; but the difference in tone between a piece of glass and a piece of aluminium electrographed on the same plate, was so trifling as to show that the tube would not be worth the trouble of making. An aluminium tube would be very difficult to insulate. Other English tubes I have tried give good results for a time. The mouse was done with one which gave the proper green light, but which heated so that it had to be worked a quarter of a minute at a time and then have a quarter of a minute's rest, thus doubling the time of the sitting. After three or four exposures it deteriorated, the whitish blue light appearing instead of the green, and a dark fatigue spot showing on the glass in the centre of what had been the brightest ring of the green light. As the tube deteriorated it gave the outline of the object with about the same exposure, but it lost some of its electrographic properties. For instance, the bones of a sparrow hardly showed, while the feathers were indicated, though not so clearly as in ordinary photography. Other tubes gave varying results, but none showed any sign of wearing for more than a few exposures. Of course, if the current is carefully regulated they last longer. The tubes now made are far smaller than my original Crookes tubes, and I cannot help thinking that no great advance will be made in this matter until some maker will give us tubes of from four and a half to six inches diameter, and as carefully finished off as the original ones. Although I should not expect anything from a tube with an aluminium window, a mica one might give very much better results, for mica is far more transparent to the new rays than glass. The focus tube now being talked of seems to me a good idea, but I cannot consider it a novelty, for the tube all my best early results were taken with is one which has a concave cathode focussing on to a piece of platinum in the centre of the tube, and is one of Crookes' original make. To many my exposures will seem inordinately long, but they represent the actual time the sitter or object remained on the table, and take no account of any waiting—treating a pause in the work as exposure, which it practically is in a live subject. I do not wish to boast, but hitherto I have never broken a tube. Atmosphere makes a difference. A tube that had worked very badly in a lecture-room overnight gave excellent results next day in a sitting-room heated by a gas stove, which thoroughly dried the air.

The theory of this subject is at present very hazy. That the phenomena are due to electrical disturbance I have insisted on from the time I made my first successful experiment. They seem to be the product of what is known as the Hertzian ray, so called because it was first investigated by a Swiss electrician, Hertz. A Hungarian professor named Lenard forestalled many of Prof. Röntgen's experiments, as the latter willingly acknowledges; but to Prof. Röntgen belongs the honour of applying the influence to physiology. What its possibilities in that way may be no one can yet foretell.

It seems that the electrical waves are longer than those of light, that they are propagated in straight lines, that they are incapable of refraction, but not, perhaps, of reflection, and are possibly not transverse but longitudinal waves. To this last idea the researches of Lord Kelvin lend colour. If this be so, before we can fully investigate this set of phenomena we shall be in the difficult position of having to divest our minds of all preconceived ideas connected with the laws of light.

Hertz showed that the electrical wave can be propagated by the ether without the intervention of what is generally known as a conductor, much as the sound made by a tuning-fork is given out by a violin string tuned to the same note and placed at some distance off. The tuning-fork gives out a simple fundamental note; the violin string gives out that note too, but, being fastened at both ends, vibrates in nodes besides vibrating as a whole, and gives rise to a host of overtones. For the tuning-fork substitute the Crookes tube, and for the violin string substitute the sensitive plate, and you have a rough and very imperfect, but possibly helpful, analogy. It is not said that this is what does occur, but merely that this helps the mind to imagine what may occur. To carry the analogy further, the electrical fundamental may be able to pass through certain substances which the shorter actinic overtones could not penetrate. When it gets to the photographic plate, it may set up not only the electrical fundamental but the actinic overtones which affect the plate. This is a clumsy attempt to explain what no one as yet understands. In an attempt to electrograph a sparrow under chloroform a piece of cotton wool was placed on the celluloid covering the plate and saturated with chloroform. This came out quite black, whereas dry cotton wool shows no more than feathers. In a further experiment to verify this, some cotton wool saturated with water, some with alcohol, and some with chloroform gave nearly similar results, while a dry piece did not show at all on the negative. This seems an added proof of the electrical nature of the rays. The area of electrical disturbance may easily be demonstrated by holding a small specimen gaseous tube, such as is used in spectroscopy, near the tube, coil, or cables, when it will be seen to glow at a distance of several inches, just as it would if it were connected to a battery. The region where it glows brightest is near the negative pole of the coil.

A paper on this matter would not be complete without some allusion to Prof. Salvioni's experiments in "seeing the invisible." I took a funnel-shaped iron tube. On a piece of black paper (such as is used for wrapping up photographic plates) I gummed an area as large as the large end of the tube. I allowed that to partially dry and dusted it over with barium platino cyanide, using about a drachm. This I attached to the iron tube by means of elastic bands. When held up to daylight or bright gas-light no ray of light appeared, but when held near the bright end of a vacuum tube a glow was seen, and a purse held between the paper and the vacuum tube showed distinctly a coin inside. The bones of the hand show clearly through the flesh, and the lead of a pencil through the wood; but the light seemed to me too dim to

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be of practical value in surgery. Prof. Salvioni's results are, however, a very striking corollary of Prof. Röntgen's discovery. In repeating Prof. Salvioni's experiments, I first tried his method of saturating blotting paper with a solution of the powder, but I think my plan gives more light. Barium platino cyanide costs, unfortunately, eight shillings a drachm, so the experiment should be cautiously made.

As bearing on the limitations of electrography with regard to surgery, I may mention that an attempt to get at the inside of an incubating egg failed. Only the graining of the shell appeared on the negative, because an egg is completely surrounded with a substance which, like bone, is opaque to the influence. If this be so, what becomes of the marvellous tales about the photographs of the inside of the living skull? If the head be electrographed, what can be obtained but a mass of bone with no definition? For the brain is surrounded by bone, except at the holes for the optic nerve.

As far as electrography has gone, its uses to the surgeon are little or none—at least that seems to be the opinion of the medical men with whom I have talked on the subject; but there is one way in which, even at this early stage, it is of practical use. A girl had a diseased finger-bone on which she did not like an operation to be performed. The electrograph of her hand, though showing little or nothing to the surgeon of which he was not before aware, at once convinced the patient, and the operation will shortly take place. Electrography should also save probing in wounds of the hand or foot, and, probably, at no very distant date, in any part of a limb. I think this is all that can be claimed for it at present, but even that seems a good deal for a few weeks' work.

Many people have curious notions about electrography. A parent wrote to ask if the child's diseased bone could be photographed; there would be no difficulty, as the child was very good and the room to which it was confined had a south aspect. An old lady wished to have her head photographed, for she had lately become deaf—she was not always so—and she thought it would be a good thing to know what caused her deafness; she had tried "other remedies" in vain. A student, hearing me describe my methods, interrupted with "Oh! we know all that; we have done all these experiments here." I asked to see the results. "Well"—in a tone which rebuked the irrelevancy of the question—"there were no results."

The enlargement, due to the distance of the hand from the plate in the earlier experiments, is, I am told by a psychic investigator, caused by the "Odic Nimbus." Call a spade a spade, if you will; but remember that a shadow is an odic nimbus. It is a much nicer name.

In case any reader wishes to repeat these experiments but is deterred by not knowing the cost, I may say that a ten-inch spark coil costs £40, a hand dynamo about £15, and a Crookes tube about 25s. It is not suggested that my apparatus is the best possible, but merely that good results have been obtained by its means. Where there is some means of re-charging them, accumulators are better than a dynamo, because they are less trouble and the current is more even.

Note.—Since writing the above, I have succeeded, with an improved tube, in electrographing my own hand in one minute. The bones show right down to the wrist, and the commencement of the ulna and radius is clearly differentiated. The plate was so much over-exposed that I believe half a minute would be quite enough. No Tesla transformer, nor any other apparatus than that mentioned above, was used.

NOVEL EXPERIENCE WITH RÖNTGEN RAYS.

While carrying out experiments with Röntgen rays we have obtained results which we consider worth further careful investigation.

On exposing a plate contained in an ordinary cardboard plate-box with the object of obtaining a shadowgraph of keys, coins, etc., on the top, we failed to obtain the usual image; on exposing another plate in the same box after a trifling alteration of apparatus, but with an entirely different series of objects, we obtained on development a well-defined image of the objects first exposed. Struck with this phenomenon, we made another exposure in the same box with a plate from a fresh packet, and, on developing, obtained a good image of the objects placed for the *second* exposure. We have repeatedly obtained these remarkable results under the following varied conditions:—

Exposure made and no result; box left for two days; fresh exposure made with entirely different objects, and resulting negative clearly defined objects placed in the box two days before.

Exposure made and box exposed to strong daylight, to ascertain if sunlight would discharge the latent image, but with no effect. After an interval of eight days, box was again subjected to X rays, and a negative obtained of objects exposed eight days previously.

This is at present entirely inexplicable, and as we only seem to get these retained or latent impressions with one box we have not yet subjected the cardboard of which it is composed to more than superficial examination. It is our intention to endeavour to obtain more boxes of this particular batch, and if with these we can confirm our present results, we hope to elaborate a theory which will account for what we can only now term "the storage and transformation of images formed by X rays in certain undetermined varieties of cardboard."

We may add that the apparatus used was a two and a half inch spark coil, operated by a chromic acid battery, using sometimes special Crookes tubes and sometimes a small incandescent lamp with broken filament, for producing the X rays.

Leon J. Atkinson.
Arthur H. Pook.
March 18th, 1896. R. P. Williams.

ALUMINIUM: ITS HISTORY, MANUFACTURE AND FUTURE.—I.

By Samuel Rideal, D.Sc.Lond., F.I.C.

Very few chemical discoveries of the present century have evoked so much interest as that of the introduction of aluminium. At the Paris Exhibition of 1855 it was exhibited for the first time in public, and was regarded as one of the principal novelties of that year. The new metal was shown as a bar, bearing the very sensational inscription, "Silver from Clay," and was regarded even at that date as the metal of the future, with boundless possibilities of usefulness. The non-scientific press devoted long articles to its description, and pointed out that a metal with apparently all the qualities of the noble metals, and excelling them in having a remarkably low specific gravity and in its general stability, had been produced from one of the most abundant materials on the surface of the earth; and the inventors of the process were hailed as benefactors to humanity and honoured as accomplishing one of the greatest achievements of science. The first

burst of enthusiasm was, however, soon abated when the enormous cost of production of the new metal was realized; but it was still confidently expected that, with further work, the price of the element would soon be much reduced, and that from being a laboratory curiosity it would then become one of the principal items of metallurgical industry. Notwithstanding this stimulus to research, and the very considerable attention that was devoted to the elaboration of the processes then proposed for the winning of the metal from clay, progress was by no means rapid. Large sums of money were, however, subsequently expended in the erection of factories in France, England, Germany, and America; and the older processes have gradually been replaced by more modern methods, in which the progress which has been brought about in the perfection of electrical plant, coupled with the utilization of the cheap energy of waterfalls, has been made to contribute to the manufacture of this element, with the result that, whereas in 1856 aluminium was worth £18 per pound, and in 1886 still cost £2 8s., at the present day it can be bought at about eighteen pence per pound. The present low price of aluminium has naturally brought it into the range of metals in general use, and has allowed of its production in large quantities on a metallurgical basis, so that its adoption for the most varied purposes has at last been assured. There can be no doubt that last year's output of the metal will be largely increased in the near future, and that the dreams of the journalists of 1855 will soon be more completely realized. The exceptional position of the metal renders it of interest at the present time to review the history of its progress, as those who are engaged in its development are confident that its use will now rapidly extend in many directions which have hitherto been barred through difficulties attending not only its economical production, but also in the removal of impurities from the metal which affect its durability, and in want of knowledge which prevented the most suitable alloys from being manufactured.

The first attempts at the isolation of this metal from its oxide, alumina, were made by Davy in 1807, and some years later by Berzelius; but both of these distinguished chemists failed to obtain any satisfactory result. In 1824 Oerstedt endeavoured to decompose aluminium chloride by means of potassium amalgam; but although it seems doubtful whether his experiments were successful, he has the merit of having first conceived of the idea that an alkaline metal might be used for the reduction of aluminium compounds. The celebrated chemist Woehler, three years later, succeeded in decomposing anhydrous aluminium chloride by means of metallic potassium, and obtained the metal as a grey amorphous powder. He, however, for some unknown reason, did not continue this research until 1845, when, by passing the vapours of aluminium chloride over heated metallic potassium, he obtained a few grammes of the metal in globules as large as a pin's head, which resembled metallic silver in appearance. Owing to his extraordinary analytical skill, Woehler succeeded in studying very completely the chemical and physical properties of the metal with the small quantity he had at his disposal. It seems strange that this careful and valuable work of Woehler should not have at once rendered its manufacture on a commercial scale possible; but it would seem that the cost of the alkaline metals sodium and potassium at that time was almost prohibitive, even for pure scientific research, and that Woehler, therefore, had to be content with fully establishing the more important characteristics of this remarkable element. It thus came to pass that upwards of nine years elapsed before the commercial importance of Woehler's work was realized. In February, 1854, Henry St. Claire Deville communicated to the French Academy of Science the discovery of a new metal, obtained by decomposing aluminium chloride with potassium, being unaware that Woehler had already practically gone over the whole of this work nine years previously, illustrating how incomplete at that date was the intercommunication of scientific ideas in Europe. The publication of this paper created considerable interest in Paris, and the great importance of the discovery was at once realized. Deville, aided by the support of the Academy and of the Emperor Napoleon, who personally interested himself in the discovery, again set to work; and a few weeks later was able to announce that he had succeeded in isolating aluminium by the electrolysis of the fused chloride, and accompanied the communication with the first piece of aluminium foil which had ever been prepared. Almost simultaneously Bunsen, in Germany, published an independent account of the decomposition of aluminium chloride by means of an electric current. The new metal was thus prepared by two distinct processes; and it is only due to the fact that, as the methods for the production of electrical energy on a large scale at that time were practically unknown, the chemical process for the isolation of aluminium became the only one which was used commercially until the last ten years. Deville himself fully realized that the electrolytic process was destined to be the future commercial one, but found it necessary to devote his attention to cheapening the production of sodium for use in the chemical method of extraction, which, owing to its lower specific gravity, he thought was a more suitable metal to employ than potassium. His improvements in the manufacture of sodium resulted in its price falling from two thousand francs per kilo in 1855 to ten francs per kilo in 1858. At the same time Deville investigated the distribution of the metal in nature, with the view to the production of compounds of aluminium in as pure a state as possible, and thus created the cryolite and beauxite industries. Deville's sodium process was adopted in 1856 by a company which erected works at Amferville, near Rouen, and in 1857 fresh works were completed at Nanterre and Glacière, the former being subsequently transferred to Salindre. The first aluminium works in this country were opened by F. W. Gerhard, in 1859, at Battersea, and in 1860 Messrs. Bell Brothers began the manufacture of aluminium at Newcastle-on-Tyne, which was continued there until 1874.

Although the chemical process for the manufacture of aluminium was thus the only one adopted at this period for its commercial production, the electrolytic method was slowly being elaborated at the hands of Le Chatelier, Moncton, Gaudin, Kagenbusch, Berthaut, and other chemists; and in 1880, when Siemens invented the electric furnace which bears his name, it was soon seen that the alternative process would eventually replace the purely chemical one. The first commercial attempt to produce aluminium by means of electrolysis belongs to Messrs. E. H. and A. H. Cowles, of Ohio, whose process was tried for some years at Milton, in Staffordshire, and these works have quite recently been acquired by the British Aluminium Company. The Cowles process has, however, been overshadowed by the later invention of another American, Ch. H. Hall, whose ideas have been adopted on a most extensive scale by the Pittsburgh Reduction Company, at Niagara. By these last two improvements the manufacture of aluminium attains its mature stage of development.

Before discussing these processes at any length it may be of interest to briefly state some of the chemical and

XUM

physical properties of this element, and the native materials from which it is produced.

Aluminium is one of the most widely distributed of the chemical elements, but, owing to its strong affinity for oxygen, is never found in the free state, but exists in the form of alumina—its only oxide, $Al._2O_3$, which, combined with silica and the alkaline oxides in various proportions, forms the chief constituents of most rocks. Beauxite, a hydrated oxide of aluminium, and cryolite, a double fluoride of aluminium and sodium, also exist native in considerable quantities, and being comparatively free from impurities form the more usual source of the metal at the present time. Large deposits of beauxite are found in France—chiefly near the town of Beaux—in Styria, in Wocheim, and in various places in the North of Ireland; and last year a large factory was erected at Larne for the purpose of purifying the beauxite derived from the Antrim mines before shipment to Scotland. Cryolite exists in almost inexhaustible quantities on the west coast of Greenland, and is shipped from there to the principal aluminium producing centres.

Metallic aluminium has a beautiful white silver lustre, which becomes especially apparent when held against a polished silver plate, as the latter is then seen to have a distinct yellow colour. When impure, aluminium has a grey or bluish colour, the latter being caused by the presence of silicon. A dull matt surface can be obtained by washing the metal in a solution of caustic soda, and then, after being washed with cold water, dipping the plate in a bath of nitric acid.

It is ductile, malleable, very sonorous, and a good conductor of heat and electricity. It is as light as glass or porcelain, having a specific gravity of 2·56. It melts at about 700° C., and is not appreciably volatile. The metal is not readily oxidized, and is permanent in air, wet or dry, and, when pure, is not acted upon by water, even at a red heat. Sulphuric and nitric acids in the cold attack it slowly, but hydrochloric acid, especially if warm, dissolves it readily. The purer the metal the less easily is it attacked by acids, but alkalies have a very energetic action on the metal, evolving hydrogen and forming aluminates.

The question as to its behaviour towards organic acids, such as are to be found in wine and beer, has been carefully studied on behalf of the German army; but it would seem that they have no effect upon the metal when it is free from impurities and sodium chloride. It easily alloys with other metals, and many of its alloys are of greater utility than the metal itself. Amongst these alloys must be especially mentioned the aluminium copper alloy (which, under the name of aluminium bronze, has been in use for a great number of years), and the newer alloys, wolfaminium and romanium, which owe their remarkable physical properties to the presence of tungsten. The mechanical properties of aluminium are very remarkable. Its modulus of elasticity is ten thousand; its range of elasticity high, a bar being capable of being stretched one two-hundredths of its length before breaking. Its tensile strength is about twelve tons per square inch, and the tenacity of a wire of 0·145 millimètres section has been found to be about twenty-six pounds. The length of a bar capable of supporting its own weight is 23·040 feet, *i.e.*, equal to that of ordinary steel and more than double that of bronze.

(*To be continued.*)

WAVES.—IV.

SHIP WAVES, AND THE SOLITARY WAVE.

By Vaughan Cornish, M.Sc.

OUR knowledge of ship waves and of the solitary wave is largely based upon the researches of William Froude, John Scott Russell, and Lord Kelvin, and their treatment of the subject forms the groundwork of the present article.

When a ship moves through the water, pressure is greatest at bow and stern and least at the sides. The surface of the water accordingly rises at bow and stern and sinks down at the sides, so that the differences of level balance the differences of pressure created by the motion of the ship. Thus a moving ship is accompanied by waves. Three principal factors determine the form and character of these waves, namely: first, the motion of the ship; secondly, the motion of each wave formed by the ship; and, thirdly, the transmission of energy by these waves. As explained in the last article, the energy is transmitted at half the velocity of the wave, consequently a *group* of waves is formed. In the front of the group the waves continually die out as the energy falls behind and forsakes them; and, conversely, in the rear of the group, new waves are formed. Consequently, the rear of the procession of waves falls further and further behind the ship, and, as the ship is constantly adding new waves to the front of the procession, the vessel is accompanied by a lengthening track. As the energy of the wave motion proceeds at only half the pace of the waves (which is also the pace of the ship), the rear of the procession moves at one half the rate of the vessel. We have here two distinct velocities: that of the tail, which is the group velocity, and that of the head, which is the wave velocity. If we could

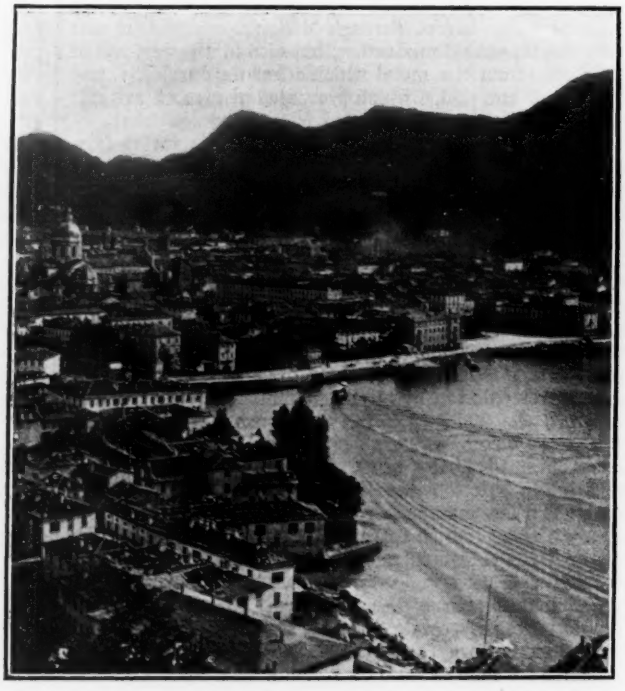


Fig. 1.—Steamer on Lake Como, showing Thwart-ship and Echelon Waves.

observe and follow a particular wave crest in the rear of the procession, we should see it advance *through* the group, and finally die out in front of the group. When a ship, preferably a steamer, moves at a sufficient speed through smooth water, the group of waves is seen to have the form shown in Fig. 1. Allowance must, of course, be made for the fact that the vessel shown in the illustration is moving in a curve. There are two sets of ship waves to be noticed, the thwart-ship waves and the echelon waves. The former are similar in appearance to a ground swell, with gently rounded crest and trough; they follow the ship at her own speed (if that remain constant), and the length from crest to crest is the length proper to a free wave travelling with this velocity. Thus, if the vessel be going at six knots, the wave-length is twenty feet; at ten knots it is fifty-six feet; at twenty knots, two hundred and twenty-three feet; and at thirty knots, five hundred feet: the wave-length being proportional to the square of the velocity. The front of the advancing thwart waves is bent in a curve, of which the radius increases as the waves travel on, the crests flattening out as the curve expands. It will be noticed that there is thus a great similarity between the thwart waves and the waves which spring out from the spot where a stone is thrown into a pond. If the motion of the vessel were suddenly stopped, the thwart waves would, of course, travel on ahead of the ship.

The extremities of the thwart waves seem to rest, as it were, upon the echelon waves. These are very different in character from the thwart waves, being steep and lumpy. They are the waves which form the lateral boundaries of the group, and by which small craft are often swamped. If we observe the echelon waves from their origin at the bow of a vessel, we find that each wave crest has no great extension from end to end, and that they are stepped back one behind the other. Each crest tapers off somewhat from the middle towards the ends, which overlap the next preceding and following crests. Thus the echelon wave pattern does not, as a careless observer might suppose, have a continuous front shaped like a long fish-head. The falling behind of the energy prevents this, the crest continually dying out in front and a new crest forming behind. The distance between the crests of the echelon waves is that proper to so much of the ship's forward motion as is in the direction of advance of the waves. This is a small fraction of her speed; and

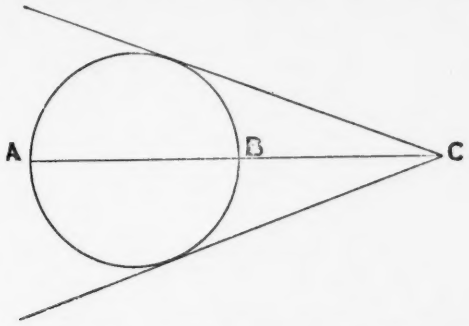


Fig. 2.—Diagram showing the enclosing angle of a Ship's Track.

the wave-length being proportional to the *square* of velocity, we find the crests of the echelon waves from steamers to have generally a length of not more than, say, two feet from crest to crest.

The outline of the whole wave pattern is the same whatever be the speed of the ship. Thus, let a circle be drawn (Fig. 2), and a diameter A B be produced to a point C, such that the length B C is equal to the diameter A B. From C let tangents be drawn to the circle. Then if C be the bow of the ship, the whole pattern will be included within the tangents drawn from C.

Hitherto we have spoken only of the waves originating from the bow of the ship, but at the stern also the pressure of the water reaches a maximum; there is a hump of water near the stern as well as near the bow, and from the stern there originates a wave pattern similar to that from the bow. The two systems of echelon waves are fairly easy to discriminate, but the two systems of thwart waves are very often undistinguishable from one another. Sometimes, however, if the ship have a long parallel-sided middle body, the thwart waves due to the entrance or bow part have flattened out so much before the run, or stern part, of the ship is reached, that the series of thwart waves due to the stern part can be separately distinguished.

The steam-tugs which ply upon the Thames at London give a fine display of ship waves, especially when going at full speed without any barges in tow. At such times the water rises almost to the level of the deck at bow and stern, while amidships the sides are visible much below the water line. Standing upon one of the bridges one may look down upon the conspicuous echelon waves which form a long track behind the vessels, and which sometimes are of such height and power that they send a surf flying over the landing piers. The thwart waves, with their greater length and gentler slope, are less easy to observe at a distance from the vessel. I have found the steamboat pier near Westminster Bridge a good post for the observation of these waves. After a tug has passed under an arch of the bridge the thwart waves may be seen in profile against the sides of the arch, and their forward motion can still be watched when the vessel has gone nearly a quarter of a mile upon her course. Thwart waves may also be well seen in profile against the side of a long steamer in motion, as is shown in our illustration in the March number of Knowledge (page 54).

If the length of a vessel be known, her speed may be calculated from observation of the length between the crests of the thwart waves as shown by her wave profile. This follows from the connection between wave-length and velocity, the length being proportional to the square of the velocity. If at any particular velocity the wave-length be such that the crest of the wave formed by the entrance of the ship coincides with the crest of the wave formed by the run, or stern part, this velocity is unfavourable to the ship, owing to the great amount of the ship's power which is expended in wave-making. On the other hand, a velocity such that the crest of the wave due to the bow coincides with the trough of a wave due to the stern is a favourable velocity, since the two sets of waves tend to annul each other, the wave-making resistance being thereby diminished. For this reason a curve showing the total resistance experienced by a vessel at different speeds has a series of humps and hollows, depending upon the periodic variation in the wave-making resistance. Again, if a ship be designed for a certain speed, it is advisable that her length should be such that the crests of bow waves and stern waves should not coincide. As far as the skin resistance is concerned it is said to be best for a ship to be all entrance and run, with no parallel-sided middle portion; but the parallel middle body is an advantage where increase of length is required to prevent coalescence of the two wave systems.

Ducks when swimming show the echelon waves beautifully (Fig. 3), and there are no better places to see "duck waves" than the Serpentine and the water in St. James's Park. To get a good general view of the whole track of

waves my favourite post of observation is the bridge near the Magazine; whilst for a near view, and to observe the "wave profile" of the duck, I prefer to walk by the edge of the water in St. James's Park, where one is sure to be

Fig. 3.—Ducks swimming, showing Echelon Waves.

accompanied at one's own pace by a duck on the look-out for food, the ducks in St. James's Park being both tamer and greedier than those of the Serpentine. The wavelets or ripples which form a fringe in front of the bow wave should be noticed; also the rise of water at chest and tail and its sinking "amidships" when the duck darts forward for a piece of bread. Very pretty also is the interlacing of the wave tracks when a whole fleet of ducks moves off together, especially when the sun is low and the slanting rays give lights and shadows to the waves.

In canals, the heavily-laden barges dragged by horses move too slowly to generate a system of waves; but when there is steam navigation upon a canal, or when lighter boats travel more quickly than the laden barges, a train of waves may be seen to follow the vessel. With higher speeds the wave-length increases, and the disturbance due to an even moderate velocity reaches the bottom of the canal. The surface particles can then no longer swing freely in a circular orbit, for they feel the effect of the bottom, communicated through the water particles which swing in their respective orbits at intermediate depths. As the motion of the swinging particles departs more and more from the original circular, uniform movement, the rear of the procession of waves travels at a rate more nearly equal to that of the boat. This is due to the fact that, as the motion of the swinging particles increases in a horizontal direction relatively to the vertical motion, the proportion of the energy of motion which is handed on at each swing is increased. When the wave-length has increased until the vertical motion of the swinging particles is very small in comparision with the horizontal motion, practically the whole of the energy is transmitted. For a canal of any given depth there is a particular wave velocity corresponding to this condition. If by any means there be instituted a train of waves following one another with this velocity there will be no lengthening out of the train of waves, for the energy does not fall behind the wave, but is transmitted with the velocity of the wave itself. Each wave crest travels on with undiminished height, except for the inevitable loss of energy which takes place through friction. Such a wave is termed a *solitary* wave, because it is capable of existing by itself without giving rise to a group of waves. When the critical velocity has been reached there is no distinction between the group velocity and the wave velocity. Perhaps it would be more correct to say that when the critical velocity is reached there is no such thing as a group of waves, since each single impulse creates only a single wave; and if a number of such waves be created by a succession of impulses each wave remains "solitary," for it neither parts with nor does it receive energy to or from the following or preceding waves.

To return to our canal boat. As the velocity is increased the rear of the group of waves moves more and more nearly at the rate of the boat itself. At a greater velocity the boat is followed by a shorter train of higher waves. At the critical velocity the wave created by the bow of the boat moves along with the boat; the energy of the wave does not fall behind so as to create a train of waves, and if the boat continue to move at the proper speed no new waves are formed. This fact was discovered many years ago, on the Glasgow and Ardrossan Canal, through the accident of a horse taking fright and bolting with a light canal boat in tow. When the horse galloped off with the boat it was observed that the foaming surge which used to devastate the banks had ceased, and that the vessel was carried on through comparatively smooth water *with a greatly diminished resistance*. The value of the discovery was at once perceived, and fly-boats, as they were called, were introduced upon the canal for the rapid conveyance of passengers. The boat, which was drawn by a pair of horses, was started slowly; at a given signal it was by a sudden jerk drawn up onto the top of the bow wave; and the horses were then kept at a trot or gallop, going from seven to nine miles an hour, the boat riding smoothly and easily upon a lump or hillock of water. Wave-making resistance was done away with; the horses had only to overcome skin resistance. After the critical velocity has been attained the only thing like a wave which is to be seen is the solitary hump or hillock of water upon which the boat rides. If the boat be stopped this hillock of water travels on as a free wave. Mr. Scott Russell has described the occurrence as follows:—"When the boat stopped . . . the mass of water . . . accumulated round the prow of the vessel in a state of violent agitation; then suddenly leaving it behind rolled forward with great velocity, assuming the form of a solitary elevation—a rounded, smooth, and well-defined heap of water, which continued its course along the channel apparently without change of form or diminution of speed. I followed it on horseback and overtook it rolling on at a rate of some eight or nine miles an hour, preserving its original figure, some thirty feet long and a foot to a foot and a half in height. Its height gradually diminished, and after a chase of one or two miles I lost it in the windings of the channel."

This is the free solitary wave, which is most generally known in the form of the low, foaming ridge which slides in upon a flat beach after the bursting of a breaker, as shown in our illustration in the February number of Knowledge. Here, by the shore, may be seen the more rapid progress of the solitary wave in deeper water, for the hinder ridges are constantly catching up those in front, which are in shallower water.

It remains to explain why the critical velocity of a canal boat depends upon the depth of the canal, being greater for greater depths. The change from oscillating wave to solitary wave depends upon the change from a circular swing of the water to a backward and forward

swing with very little vertical motion. The disturbance of the water in the case of an oscillating wave reaches to a depth of, say, one wave-length. It is true that the surface particles do not descend in their swing to a depth of more than, say, one-tenth of this distance; but each swinging surface particle puts in motion a particle beneath it, so that below any point of the surface there is a vertical column of swinging particles, the amplitude of swing diminishing rapidly with the depth. A certain depth, about equal to the length from crest to crest, is therefore necessary for the free motion of a typical deep-water wave, in which the swing is circular and in which the energy advances at half the velocity of the wave. When the depth of water is much less than the wave-length corresponding to a certain velocity, a boat moving at that velocity will no longer generate a circular swing in the water; the bottom of the canal interferes with the vertical component of the swing, much as a vertical breakwater annuls the horizontal component when it converts a travelling wave into a stationary wave. (See Knowledge for February.) Under these conditions almost the whole of the swing is horizontally backwards and forwards, very little vertical motion remaining. The moving hillock of water, which is the visible thing about the transmission of a solitary wave, travels along the surface of the canal, the actual particles of water in the hillock constantly changing the while, for the march of the hillock is a true wave progression effected by transmission rather than translation. The hillock will have vanished from over section A (Fig. 4), and will surmount the section B, when a quantity of water equal to that contained in the hillock has passed from section A to section B. The rate at which this will be effected depends upon two things—the difference of pressure and the cross section. Now, as the hillock extends across the canal we need not concern ourselves about the width of section, but only about its depth. The given difference of pressure will effect the transference of a given bulk of water across each unit section in each unit of time, and, therefore, as the depth of the section is increased the given bulk of water will be more quickly transferred from section to section. Hence the relation between the depth of the canal and the velocity of the solitary wave. Following this principle, a short mathematical investigation shows that the (horizontal) velocity of a free solitary wave in a canal is equal to the (vertical) velocity which a body would acquire when falling freely in air through a distance equal to half the depth of the canal. Thus, for example, if the depth be eight feet, the velocity of the solitary wave is eleven miles per hour. This is the velocity of free propagation of any *long wave*, such as the tide wave, in which the motion of the water particle is mainly horizontal, and in which the water is equally disturbed throughout its whole depth. To the subject of the Tide Wave we return in our next article.

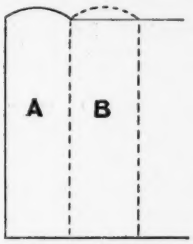


Fig. 4.—The Propagation of the Solitary Wave.

Notices of Books.

An Exercise Book of Elementary Practical Physics. By R. A. Gregory, F.R.A.S., Oxford University Extension Lecturer. This is quite an elementary book, and must be intended for very small boys. It is, moreover, said to be arranged according to the syllabus of the Headmasters' Association. The plan may appeal to some, but it seems rather suggestive of cramming. Why is it thought necessary to perpetuate the obsolete phraseology of antiquated text-books on mechanics, which treated "power" and "weight" as things of the same character, and confounded "force" and "pressure"?

The Cambridge Natural History. Peripatus, Myriapods, Insects. By A. Sedgwick, M.A., F.R.S.; F. G. Sinclair, M.A.; and Dr. David Sharp, M.A., F.R.S. (Macmillan.) Illustrated. 17s.

Of the five hundred and eighty-four pages in this new volume of the "Cambridge Natural History," only twenty-four are devoted to an account of *Peripatus* by Mr. Sedgwick, and fifty-one to Mr. Sinclair's essay on Myriapods, the remainder being taken up with the first part of an original and strikingly attractive description of insects.

Peripatus is interesting because it is a kind of half-way animal between the *Arthropoda* and *Annelida*, though it really belongs to the former group, and only possesses Annelidan affinities. Mr. Sedgwick is a distinguished authority upon the genus he describes, and his brief essay on the features, habits, anatomy, development, and distribution of it is clear though necessarily special.

Mr. Sinclair's article on the *Myriapoda* is a valuable summary of the natural history of this group. The classification adopted is that of Koch, with two orders added, viz., *Symphyla* and *Pauropoda*. After describing the general characteristics of the whole group the distinctive features of each of the orders are studied, the account concluding with sections on the embryology and palæontology of Myriapods.

Dr. Sharp's work on insects is a masterpiece, as valuable to zoologists as it is to entomologists. The part now given includes the *Aptera*, *Orthoptera*, *Neuroptera*, and a portion of *Hymenoptera*. It is full so far as it goes, trustworthy, interesting, and in every respect satisfactory, and ranks high among the best literature of the subject ever published. Every naturalist, and everyone interested in natural history, should strive to add Dr. Sharp's work to their libraries.

The volume is well printed and excellently illustrated, and is a worthy addition to what will undoubtedly become a standard series.

The Origin of Plant Structures by Self-adaptation to the Environment. By the Rev. George Henslow, M.A., etc. (Kegan Paul.) 5s. This seventy-seventh volume of the "International Scientific Series" carries on the argument set forth by the author in a work published in the same series in 1888. The Darwinian hypothesis assumes (erroneously, according to Prof. Henslow) that plants, when they vary, do so indefinitely in nature, and that the variations which are of service under any particular environment survive and are perpetuated, so that natural selection and heredity may eventually lead to the production of new species. Prof. Henslow denies that natural selection plays any part in the origin of species. He holds that a change of environment induces a plant to form *definite* and not indefinite variations in nature, which are, therefore, always in the direction of adaptation to the surrounding circumstances of life. Environment in its widest sense, and "the responsive power of protoplasm," are thus held to be the causes of adaptive variations in plants, and natural selection is put out of court. In the present volume this view is applied to account for the origin of vegetative structures, as it was used in the former one to that of floral structures. The cases studied by the author to show that definite variations are produced by the responsive action of the protoplasm in various species of plants, called into play by the external forces of the environment, are

desert plants, alpine and arctic plants, maritime and saline plants, phanerogamous aquatic plants, subterranean structures, climbing stems, and leaves. A wealth of facts with reference to the structural peculiarities of these plants are described and explained from Prof. Henslow's point of view. The argument is always ingenious and often convincing, and, though we are not inclined to accept it in its entirety, we regard it as affording a strong case against natural selection. But whether Prof. Henslow's views are accepted or not, we cordially commend his book to all who study the biology of plants.

Report of the Total Eclipse of the Sun, observed at Mina Bronces, Chile, on April 16th, 1893. By J. M. Schaeberle (University of California). Illustrated. The excellent results obtained by Prof. Schaeberle during the total solar eclipse of April, 1893, and the fact that a large number of astronomers are making preparations to observe the eclipse which will happen next August, makes this volume a very valuable one, published at an appropriate time. The volume contains a narrative of the expedition, reports of individual observers, several good illustrations of the corona reproduced from photographs, and a discussion of the results by Prof. Schaeberle. It will be remembered that the attention of the expedition was entirely devoted to the corona, so the discussion is practically limited to coronal structure. In a "Mechanical Theory of the Corona," put forward by Prof. Schaeberle in 1890, it was suggested that all the coronal matter was ejected in streams normal to the sun's surface, and that the various appearances presented by the corona during different eclipses were produced by differences in the terrestrial point of view. This theory has, however, been slightly modified in order to accommodate it to the facts revealed by the photographs of 1893, and Prof. Schaeberle now concludes that "all true stream lines can be made to coincide with elliptical arcs having one focus at the sun's centre, the origin of the streams being, in the main, confined to the spot-zone regions." Contrary to the opinion of many solar physicists, he thinks that neither electricity nor magnetism have anything to do with the arrangement of coronal matter in the sun's neighbourhood; indeed, if all the stream-lines have the form which Prof. Schaeberle describes in the foregoing extract, it is unnecessary to introduce electrical and magnetic forces to account for them. How far the views will stand the test of future knowledge is not for us to decide, but at any rate they help to direct attention to the structure of the sun's surroundings, and so assist in the advancement of solar physics.

The Aëronautical Annual. Edited by James Means. (Clark & Co., Washington Street, Boston.) One dollar, post free. The general public, as well as literary men, leader writers, and even some scientific people, entertain very vague and erroneous ideas as to the results likely to arise when man has succeeded in navigating the air. To all such we would strongly recommend a careful perusal of Mr. Means' new annual for 1896. In this volume (the second annual) Mr. Means has most industriously brought into notice the result of a year's work, and has produced a very instructive and readable book. Under twenty-one separate headings, with sixteen well-executed plates (including an excellent likeness of Mr. Octave Chanute) and numerous woodcuts, the subjects are rendered very clear for the reader. M. Lilienthal contributes some novelties in his particular department of flight; Mr. Maxim treats of the allied subjects of natural and artificial flight; Mr. Chanute takes up the subject of sailing flight, Prof. Pickering takes up the subject of bird soaring, Mr. Herring dynamic flight, and Mr. Lawrence Rotch the relation of the wind to aëronautics. Not the least interesting portions of the book are those in which various kinds of kites are well described and illustrated. While the annual proves that real progress is being made, it also shows that very much remains to be accomplished before aërial flight can be rendered practical; and those who look upon it as a mere instrument of war will have to wait a very long time.

SHORT NOTICES.

The History of Babylonia. By the late George Smith. Edited and brought up to date by Rev. A. H. Sayce. (Society for Promoting Christian Knowledge.) 2s. A valuable handbook for students. It possesses a list of Babylonian kings with their approximate dates, and has a useful index.

Frail Children of the Air. By Samuel Hubbard Scudder. (Boston: Houghton, Mifflin, & Co.) Illustrated. $1 50c. In this book a number of interesting facts in relation to butterflies, and especially American species, are discussed and explained. The book is free from technicalities, and will be valued by all amateur entomologists.

Popular Readings in Science. By John Gall, M.A., and David Robertson, M.A. 2nd Edition. (Constable.) 4s. A number of subjects of fundamental importance in science are treated of in a fairly popular way in this volume, and we would recommend it to those who wish to gain a general knowledge of important scientific subjects.

The Climates of the Geological Past, and their relation to the Evolution of the Sun. By Eug. Dubois. (Swan Sonnenschein.) 3s. 6d. This is a translation of a treatise in German and an essay in Dutch, purposing to explain the climatic changes of past ages by changes of the solar heat.

Annuaire Astronomique et Météorologique pour 1896. Par Camille Flammarion. (Paris: Plon, Nourrit.) Illustrated. 1f. 25c. Contains a description of every celestial phenomenon observed during the year 1895.

Mechanics, Hydrostatics. By R. T. Glazebrook, M.A., F.R.S. (Cambridge University Press.) Is an excellent elementary text-book, and will be found of great use for colleges and schools, since it deals both practically and theoretically with the subject.

The Koh-i-Nur Diamond. By Edwin W. Streeter. (Bell & Sons.) Illustrated. Contains an interesting description of this celebrated diamond and its history, and also of the Pitt diamond.

The Story of the Earth in Past Ages. By H. G. Seeley, F.R.S. (Newnes.) Illustrated. 1s. This little book, which is a wonderful production for the price, deals pleasantly and plainly with many facts in connection with the earth in the geological past.

Weather and Disease. By Alex. B. MacDowall, M.A. (Graphotone Co.) Is a very interesting compilation, illustrating by means of curves the history of the variations of weather and disease in recent years. It will furnish useful data for comparison and study to those interested in the subject.

An Introduction to Chemical Crystallography. By Andreas Fock. Translated from the German and edited by W. J. Pope. Is so arranged that the twenty-five brief chapters each elucidate a single idea, and Mr. Pope's excellent translation and revision will bring it within the reach of university and other students.

We have lately received a number of new catalogues, all excellent in their way, from different makers of scientific instruments. The chief features in Messrs. Newton's, Messrs. York & Son's, and Messrs. Wilson's catalogues are their gigantic lists of magic-lantern slides, comprising series of almost every subject of scientific interest. Mr. J. H. Steward has issued a pamphlet entitled "How to Assist the Sight," which admirably explains the uses of spectacles and eyeglasses of every kind. Messrs. Ross & Co. have several novelties in their catalogue, amongst which we might mention their new Eclipse microscope and new Science lantern, the former as an excellent cheap microscope and the latter as a very complete and perfect lantern. Messrs. Horne & Thornthwaite's astronomical instruments range from the plain and inexpensive to the high class and perfect. Messrs. Banks & Co.'s catalogue contains an excellent list of astronomical instruments suitable for amateurs, and that of Messrs. Steinheil Söhne a number of binoculars and telescopes. Messrs. Thornton-Pickard have also sent us a catalogue, the illustrations in which prove the efficiency of their shutters.

BOOKS RECEIVED.

Discoveries and Inventions of the Nineteenth Century. By R. Routledge, B.Sc. 11th Edition. (Routledge.) Illustrated.
Outdoor Life in England. By Major A. T. Fisher. (Bentley.)
British Moths. By J. W. Tutt, F.E.S. (Routledge.) Illustrated. 5s.
Moorland Idyls. By Grant Allen. (Chatto & Windus.) 6s.
On Seedlings. By Sir John Lubbock. International Scientific Series. (Kegan Paul.) Illustrated. 5s.
A Child's History of Scotland. By Mrs. Oliphant. (Fisher Unwin.) 2s. 6d.
Segnius Irritant; or, Eight Primitive Folk-lore Stories. By W. W. Strickland. (Forder.) Illustrated.
The New Photography. By A. B. Chatwood. (Downey.) Illustrated. 1s.

Science Notes.

At a recent meeting of the Royal Geographical Society, Mr. Clements R. Markham being in the chair, Dr. H. R. Mill read a paper on "A proposed Geographical Description of the British Islands, based on the Ordnance Survey." In the course of an interesting and comprehensive address the lecturer advocated the preparation of a complete geographical description of the British Islands, somewhat upon the lines laid down by him recently in our columns. (Knowledge for January, 1896.) In the discussion which followed, Sir Charles Wilson and Colonel Farquharson both commended the project, while Mr. Clements Markham looked upon the matter as one of the greatest importance, and undertook to recommend to his Council that the work should be carried out under the Society's auspices. We may mention that Dr. Mill has promised to continue the discussion of the project in our columns a little later on.

At the observatory of the Pic du Midi the zodiacal light is always visible on clear moonless nights, and E. Marchand has, during the last three years, made careful observations upon it. It is not confined to a fusiform region in the neighbourhood of the sun, but continues that region right across the sky as a faintly luminous track, always dimmer than the Milky Way at its dimmest. The cosmic matter surrounding the sun extends far beyond the earth's orbit in a very much flattened ellipsoid, but is especially condensed in the neighbourhood of the sun, and forms there the more brightly luminous fusiform zodiacal light as usually seen in the morning or evening.

The fifth annual report of the Society for the Protection of Birds, which has been sent to us by the hon. secretary, is a very satisfactory one. It shows that the Society is increasing and that it is doing really good work, not only in promoting bird protection, but in spreading a knowledge of bird life by lectures illustrated with lantern slides. By thus interesting and educating the public in birds, the Society will be better able to put an end to the destruction of our feathered friends than by mere legislation.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE RED SPOT ON JUPITER.

To the Editors of Knowledge.

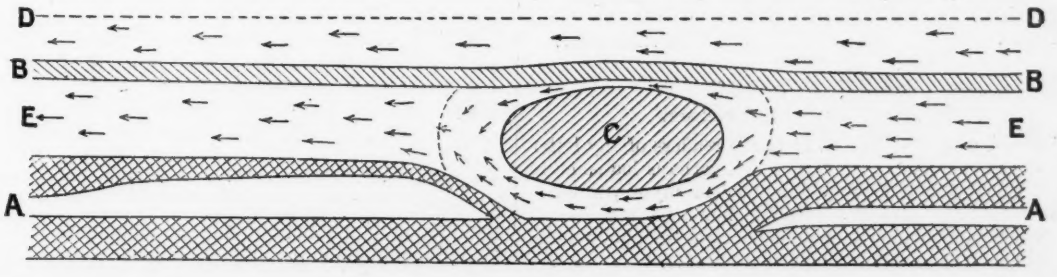
Sirs,—I have just been reading the interesting article on the "Red Spot on Jupiter," by Mr. Maunder, in the January number of Knowledge. There is necessarily a great deal of mystery as to the nature of the spot; nevertheless I cannot help thinking that it actually acts in the same way as, and has some analogy to, an island in a river. The following rough diagram may make this plainer.

Here A is the S. equatorial belt, the material of the southern portion of which rotates at approximately the same rate as the red spot; B is the S. temperate belt; C is the red spot or island. The whole of the surface material in the zone E, between A and B (and also for some distance south of B), drifts past the red spot in the direction of the arrows with a velocity of sixteen miles per hour. (This is Zone VIII. of my paper on the drift of the surface material of Jupiter in different latitudes, in the January number of the *Monthly Notices*.)

When the white material in the zone E encounters the red spot or island C, it meets with an insurmountable obstacle, and is obliged to force a passage *round* C, which it does chiefly on the north side by forcing the south equatorial belt A northwards. A portion of the white material also usually passes in the narrow channel on the south side of the spot.

The reason why the main channel lies on the north side of the spot would appear to be because the material is in a more plastic state near the equator than it is nearer the poles. (This is also indicated by the well-known fact that the equatorial parts of the planet are the chief seat of disturbance and change, and the region of greatest spottedness.) So that there is less difficulty in forcing A northwards than B southwards.

Here comes an important point. The channels north and south of the red spot are together narrower than the main channel E following the spot. The effect of this is to cause the white material to be heaped up in the region



just following the spot, and also in the channels north and south of the latter; and these regions therefore appear whiter than the average, owing to the greater depth of white material, thus producing the bright annulus encircling the red spot. In the region just preceding the latter, the meeting of the two currents causes eddying and commotion of the white material before it finally flows off along the now broad channel E preceding the spot. The result of this eddying and commotion is to make appear

here the bright indefinite patch (part of the annulus) usually visible, even when the rest of the annulus is comparatively inconspicuous.

You will see that this theory seems to account for:—(1) The apparent repulsion of the S. equatorial belt, resulting in the great bay opposite the red spot; (2) the well-known shoulder following the latter; (3) the bright annulus surrounding the red spot; (4) the bright patch (forming part of the annulus) usually visible at the preceding end of the spot; (5) the broad bright channel always seen separating the spot from the S. equatorial belt. And all this in the simplest way possible.

It is true that I cannot imagine what kind of a constitution the red spot can have to act as such a substantial obstacle, and yet to drift about as it has done. Nevertheless it seems to me that the foregoing is worth suggesting as a working hypothesis, especially since there appears to be no theory which is not open to serious objections.

Until lately I was a little doubtful whether the white material in the channel north of the spot does move in accordance with the above hypothesis, but according to a letter just received from Herr Brenner, of the Manora Observatory, there appears to be no doubt of this.

A. Stanley Williams.

MIRA CETI.

To the Editors of Knowledge.

Sirs,—Unfortunately the weather seems to have hindered the observation of this star for a week in the early part of January, and I only know of a few observations of it made afterwards until the middle of that month.

On the 9th I compared the brightness of Mira with that of δ Ceti, and the former appeared to have the benefit in a slight degree. This would make its magnitude not much above the fourth order, at which it was placed by Mr. David Flanery on January 8th.

On January 10th I again observed the star, and placed its magnitude at nearly that of γ Ceti, there appearing to have been a rise of almost half a magnitude in the twenty-four hours.

A few dull evenings then intervened until the 15th, when I could find no appreciable difference between Mira and γ Ceti, although on the 19th the latter seemed to me to be very slightly the brighter.

From that date I have made very few observations of Mira under favourable conditions, but at the end of February no remarkable decrease in its magnitude was noticed.

Exeter. W. E. Besley.

PENTACLE PUZZLE.

To the Editors of Knowledge.

Sirs,—I owe an explanation to the readers of my letter (Knowledge for March, p. 63), which perhaps led some to think I had actually solved the problem myself, whereas it was simply tentative. But I fear the problem is insolvable in its complex statement, and perhaps also in the simple statement touching the summations of the five lines only.

I would suggest that possibly the law may be that such results occur only when the lines of the figure chosen are parallel.

I find further that this problem goes very much on the same lines as the endeavour to find *exact* relations between the radius and the periphery of a circle.

Brighton. I. G. Ouseley.

[Note.—It has been pointed out by several correspondents that the sum of the numbers 1 to 10 being 55, which is indivisible by 3, the sum of any five of the numbers cannot be double or half the sum of the remaining five; and since in the problem the five external numbers are to count double the five internal numbers, the problem is insolvable.—Eds.]

ZODIACAL LIGHT (?).

To the Editors of Knowledge.

Sirs,—I venture to write you respecting an unusual phenomenon witnessed by myself on the outskirts of this town on the evening of March 4th. Happening to look westwards I saw a solitary bright streak of light (in width apparently about 5°) issuing from behind a dark cloud on the W.N.W. horizon, and stretching almost half-way to the zenith.

This was at 8.30, and it remained very bright for three minutes (so bright, in fact, that a light cloud passing over it did not entirely hide it from view), when it gradually faded away to a glimmer, and in ten minutes no trace was to be seen.

Both sides of the streak were well defined, and were parallel to one another throughout the whole length. It attracted the attention of all passers by, who stopped to look at it, and were asking what it could be. Was this the zodiacal light? If so, it was very bright, and was hardly at all inclined to the horizon. It was certainly not caused by any terrestrial agency.

Shrewsbury. W. Lyon Browne, Jun.

"26" PUZZLE.

Note.—We are informed that the publication in our columns of possible solutions of this clever puzzle constitutes an infringement of the copyright; we therefore willingly express our regret to Messrs. T. Ordish and Co., 99, Fore Street, London, E.C. (Publishers), and also to Messrs. Joseph Wood Horsfield & Co., of Dewsbury, the proprietors of the puzzle, for any infringement of their patent or copyright inadvertently committed in the pages of Knowledge.

PLINY AND CUVIER.

By E. Walter Maunder, F.R.A.S.

THE two lunar photographs which we reproduce in the present number of Knowledge are, like those which we gave in June, 1895, from enlargements by Dr. Weinek of a photograph taken by MM. Loewy and Puiseux with the large equatorial coudé of the Paris Observatory on March 14th, 1894. Dr. Weinek's photographs were on a scale of four mètres to the lunar diameter, a magnification of 23·36 times linear. The present reproductions are on a scale of 2·9 mètres to the lunar diameter.

The two districts shown are sharply contrasted in character. The left-hand picture shows the borderland between two of the principal *maria* or grey plains—the Mare Tranquillitatis and the Mare Serenitatis—and shows a country mostly open, and but little diversified or broken up. The one on the right hand, on the contrary, is taken from far within the great disturbed region of the Moon which has its centre in Nasireddin, a region strewn with crater-pits and full of overlapping and interlaced formations.

The object occupying the centre of the first picture is

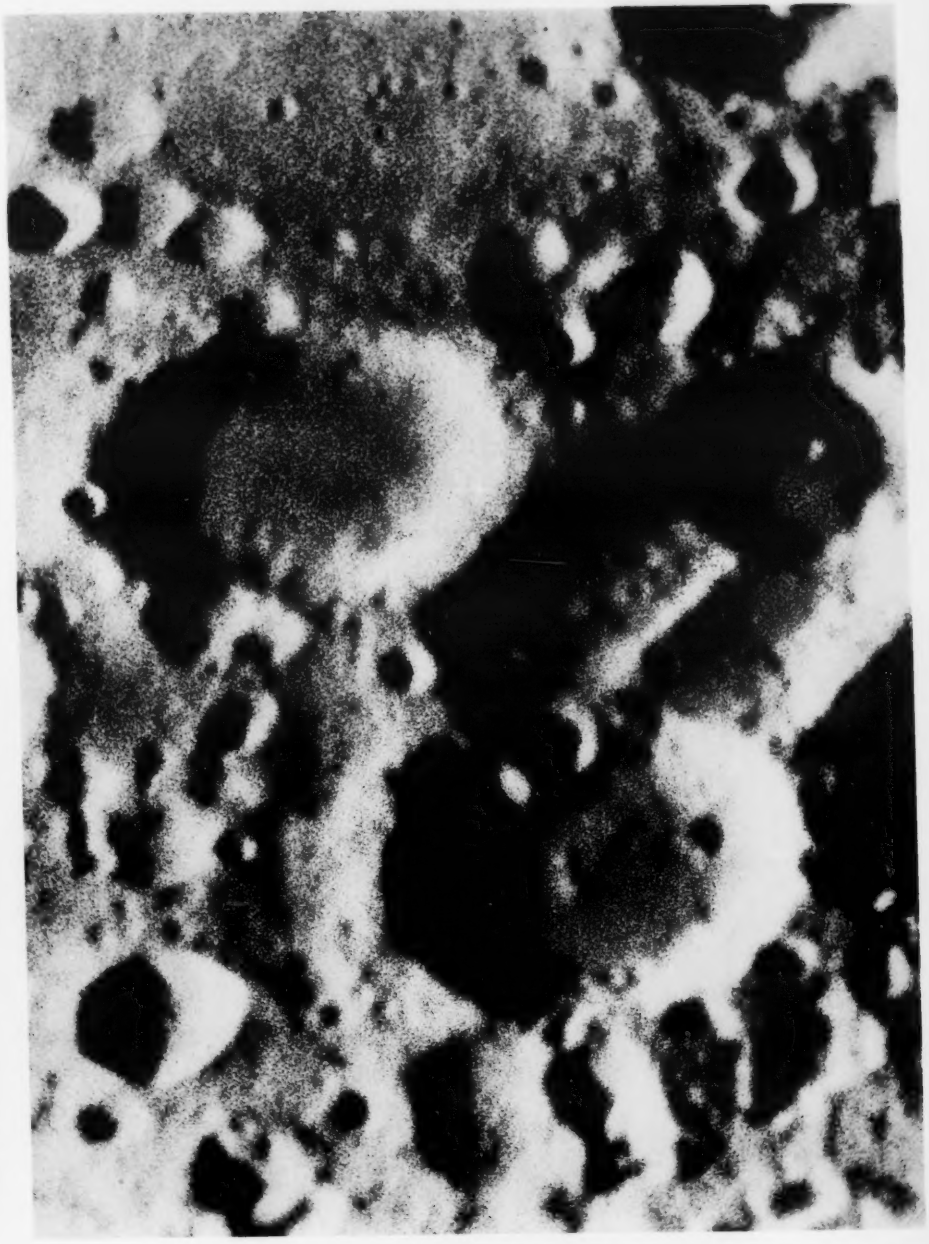
XUM

SOUTH.

NORTH.

PLINIUS.

SOUTH.

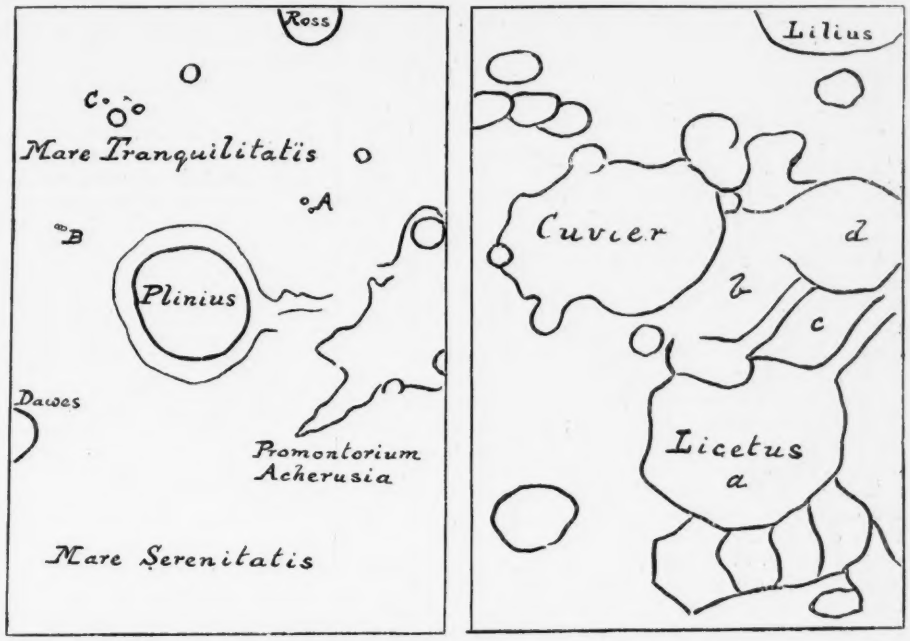


NORTH.

CUVIER and LICETUS.

From Enlargements by Dr. L. WEINEK of a Photograph of the Moon taken by MM. LOEWY & PUISEUX with the 60 c.m. Equatorial Coudé of the Paris Observatory, 1894, March 14th, 6h. 33m. 57s. Paris Mean Time.

Plinius, a fine terraced ring-plain some thirty-two miles in diameter, which, on a smaller scale, bears much the same relation to the chief "seas" in the western hemisphere that the superb formation Copernicus does to those in the eastern. Both, completely ramparted rings of especially massive construction, appear to be strategically placed so as to dominate the approach to the neighbouring plains; and Mr. Elger, in his recent and valuable work on the Moon, is led to speak of Pliny as reminding him "of a great fortress or redoubt erected to command the passage between the Mare Tranquillitatis and the Mare Serenitatis." The rampart of Pliny is not, however, raised to any great height above the surrounding country, though its highest point, clearly seen on the photograph on the east wall of the ring, rises some six thousand four hundred feet above the floor of the interior; which is thus considerably depressed below the level of the general surface in the neighbourhood. The floor of the interior is broken up by many hillocks, and two bright hills of very considerable height occupy the centre. They are distinctly shown in the photograph. The southern side of the wall slopes very gradually down to the plain outside, forming an extended glacis some ten or twelve miles broad.



Key Map of Plinius and Cuvier and Licetus.

To the east of Pliny a bright mountainous region is seen—the last ridges of the Hæmus Mountains, one of the four great ranges which shut in the Mare Serenitatis, and render it the most sharply outlined of all the lunar *maria*. These mountains terminate in a great headland nearly five thousand feet high, the Promontorium Acherusia, on the northern slope of which four deep craters are very plainly seen.

North of Plinius a broad "rill" or cleft is seen on the photograph, starting from amongst the Hæmus Mountains, close under the southern slope of the great headland just mentioned, and running right across the photograph to Dawes, a bright ring-plain on the western edge of the photograph. Further north lies a second cleft inclined at a small angle to the first; whilst between the two, but not to be discerned on the photograph, is a third—faint, small, and difficult.

These rills mark the frontier line of the two great *maria*—the more southern one, the "Tranquillity," standing at the higher level of the two, a gentle slope descending from it towards the "Serenity." In the latter, "deep calls to deep," for within a broad grey margin, itself lower than the "Tranquillity," lies an inner "Serenity," deeper still, some eighty thousand square miles in area, which full of a fine, clear, light-green tint"—in Neville's words. The photograph does not, however, reach as far as this innermost region, and the dark grey margin is alone shown.

The only two other prominent features of the photograph are the two smaller ring-plains Ross and Dawes, which, following out the military metaphor, stand as outworks of Plinius to prevent its being outflanked by an invader from the south. Dawes is remarkable for standing on a broad circular platform of brighter material than the surrounding country, a feature well shown in the photograph.

The new objects revealed by the photograph are neither large nor numerous, for this is an attractive region to the selenographer, and it has been well and frequently explored. But Dr. Weinek claims that the following new features are shown:—

(A.) A double craterlet, shown as single and small by Schmidt.

(B.) A set of two, or perhaps three, interlaced craterlets.

(C.) A small doubtful object, *s*. Plinius.

It is difficult, however, to bring out these minute details in a photographic reproduction, which has itself been copied from a copy from an enlargement.

The right-hand photograph, with its mass of detail and intricate structure, is a great contrast to the simplicity of arrangement of the Plinius region. In Licetus we have not one ring-plain, but four, which, by mutual encroachment the one on the other, and the consequent partial destruction of the boundary walls, have been fused into one very irregular walled plain. The principal member of the group is *a*, the one to the north. It is some fifty miles in diameter, and is nearly circular in its real shape (it is, of course, seen somewhat foreshortened). The highest peak of the wall rises nearly thirteen thousand feet above the interior. The other chief object shown in the photograph is Cuvier, a fine walled plain of about the same diameter as Licetus *a*, and walls of about the same elevation. For the minor objects in the field the photograph itself will give more

PLINIUS.
From Enlargements by Dr. L. Weinek of a Photograph of the Moon taken by MM. Loewy & Puiseux with the 60 c.m. Equatorial Coudé of the Paris Observatory, 1894, March 14th, 6h. 33m. 57s. Paris Mean Time.

XUM

information than much verbal description. Dr. Weinek notes no new objects here.

It may be added that this photograph slightly overlaps, at its lower left-hand corner, that given of the district of Maurolycus in Knowledge for June, 1895.

THE SPECTRUM OF HELIUM.

By E. Walter Maunder, F.R.A.S.

THE first vague glimpse of the spectrum which has won so much attention during the last twelve months would appear to have been caught by Prof. Magrini at Milan, during the total solar eclipse of 1842, July 8th. A momentary glance at the corona through a flint-glass prism showed him three vivid colours, the colours which, following Sir David Brewster's theory, were then considered primary—red, yellow, and blue. No notice seems to have been taken of the observation; the observer himself seems to have laid no stress upon it. Spectrum analysis had not then made sufficient advance for it to be understood; yet it was none the less the first faint forecast of fuller observations to come. It was the evidence, could it have been then interpreted, that the "red flames," so often noticed round the dark moon in a solar eclipse, belonged truly to the sun; that they were gaseous in character; and that amongst the glowing gases which made them up, hydrogen, and a gas at that time stranger to us, were the most abundant.

Twenty-six years after Prof. Magrini's observation, in the celebrated eclipse of 1868, August 18th, the same three colours flashed out their light on the expectant observers who, at Guntoor, Jamkandi, Masulipatam, and Tenasserim, were watching the eclipse, armed not with simple prisms merely, but with complete spectroscopes attached to powerful equatorials. There is no need to quote at length the accounts which have been so often retold. Suffice it—to take one observation amongst many—that Captain Herschel, setting the slit of his spectroscope on a brilliant prominence, needed but to give "a single glance, and the problem was solved. Three vivid lines—red, orange, blue; no others, and no trace of a continuous spectrum." The problem was solved—that is, so far as the question was concerned that the prominences belonged to the sun, and were gaseous in character. The nature of the gas was a different matter, and here the evidence of the eclipse itself was incomplete. M. Janssen was confident that the red and blue lines were the lines of hydrogen; other observers thought it more or less probable; most believed the yellow line to belong to sodium: and so the matter might have rested. But impressed with the extreme vividness of the prominence lines, Janssen resolved to look for them after the eclipse was over, and was delighted to find his anticipation realized, and that they could be seen in full sunshine. Then it was an easy matter to establish decisively the conclusion he had arrived at during the eclipse, that several of the prominence lines were due to hydrogen. But it became equally evident that the bright yellow line was not coincident with either of the two dark D lines due to sodium; it was not, indeed, coincident with *any* dark line in the solar spectrum, and it lay further towards the blue than D_2 by fully twice the distance that separated the latter from its twin brother D_1.

At first the new line, D_3 as it was called, was supposed by many to be a line of hydrogen produced only under conditions which we are not able to reproduce in the laboratory. It was as constant a feature of the chromospheric spectrum as the lines of hydrogen; it rose to the same height from the sun. But more careful scrutiny showed that it did not by all means always respond to the changes and displacements shown by C and F, the undoubted hydrogen lines; and it was not long before it was acknowledged to indicate the presence of a gas unknown to us as yet here, and on Frankland's suggestion the name of "helium" was assigned to it.

Again a little over twenty-six years passed by without our knowledge of "helium" receiving any addition, until Prof. Ramsay's discovery of it, just a year ago, in the gas obtained from the mineral clèveite. The story of that discovery, and of the researches into the properties of the gas which Prof. Ramsay and other physicists lost no time in instituting, has already been well told in the pages of Knowledge by Dr. McGowan (September, 1895). The story of the complete study of its spectrum is of fully equal interest and is of more recent date. The romance of helium is not completed even yet.

It will be remembered that for a short time the identity of the gas obtained from clèveite with true solar helium was called in question. This was owing to the discovery of Profs. Runge and Paschen, of Hanover,* that the bright yellow line from the new gas was not single (as the D_3 line of the solar chromosphere was then supposed to be), but double. Dr. McGowan has already described how the observations of Dr. Huggins and Prof. Hale speedily set the question at rest by showing that the solar D_3 was double likewise, and so completely establishing Prof. Ramsay's claim to have "run helium to earth."

But this discovery of Runge and Paschen was but an incident of the work which they were carrying on with the most powerful of spectroscopic appliances, and with the utmost thoroughness and care. The spectroscope was one of Rowland's concave gratings, with a radius of curvature of over twenty-one feet, a ruled surface of six inches, and ruled with twenty thousand lines to the inch. The photographs taken with this instrument rendered it possible to measure the wave-lengths of the lines in the great majority of cases to the thousandth of a tenth-mètre, the errors of the determinations (due mainly to the unsuitability of some of the reference lines for measurements of such delicacy) lying for the most part in the third decimal place.†

In order to obtain the greatest possible brilliancy of spectrum the vacuum-tube was used "end-on," an arrangement first employed to any great extent in this country by Prof. Piazzi Smyth, then Astronomer Royal for Scotland. By this arrangement, which necessitates a special form of tube, the light from the entire length of the capillary tube is concentrated on the slit instead of that from its breadth only. The electrodes consisted of two clyinders of aluminium foil, one in each of the two wide parts of the tube, and pressing against two platinum wires, thus allowing the capillary to be viewed end-on without interruption. The end of the tube nearest the slit of the spectroscope was closed by a "window"—a flat piece of glass, quartz, or fluor spar, according to the region of the spectrum under study.

A further essential for the work, and one far more difficult to secure, was the purity of the helium gas. The chief impurity was hydrogen gas. The helium was prepared in the same way as it was originally discovered by Prof. Ramsay, *i.e.*, by boiling clèveite with diluted sulphuric acid. This was then mixed with a large quantity of oxygen, and sparked continuously for several days until a whole day's sparking caused no further contraction. The oxygen was next absorbed, and the remaining gas stored in

* *Nature* of June 6th, 1895.

† *Astrophysical Journal*, 1896, January.

a vessel provided with stopcocks, so that a small quantity could be drawn off from time to time in order to fill the vacuum tubes. The vacuum tubes were subjected to the strictest discipline before the clèveite gas was admitted to them, being completely exhausted, dried at the air pump, heated as strongly as they would bear, and a strong induction current passed through them; this treatment being repeated until the spectrum of hydrogen was no longer shown, or, if shown, only feebly.

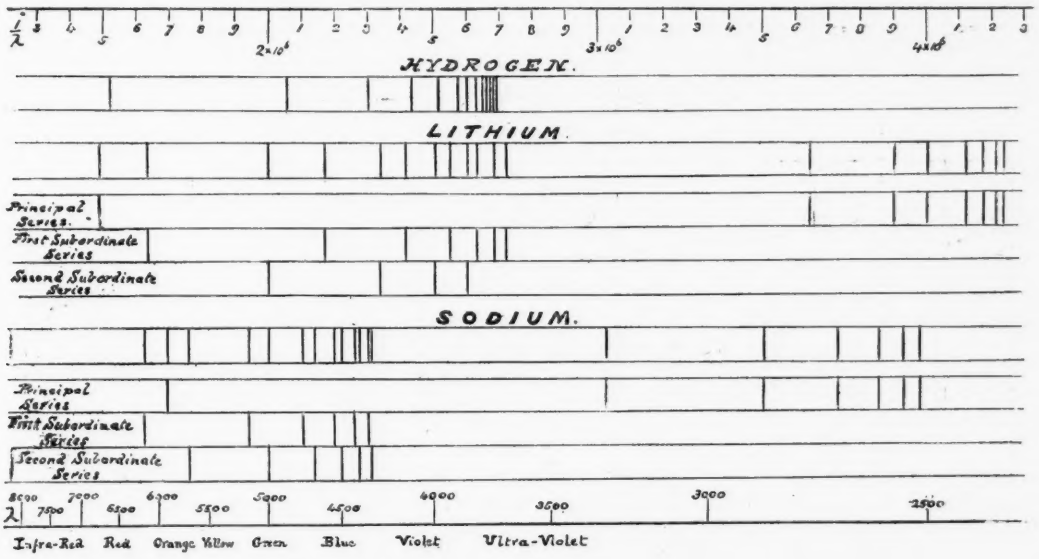
The results obtained were well worth all the trouble and time expended so ungrudgingly on the preparation of the tubes. The wave-lengths of the lines of helium were determined mainly by the measurement of photographs, the lines of sodium which were given by the vacuum tube itself when the glass got sufficiently heated, and those of iron from a pair of electrodes placed close to the slit, being the chief points of reference.

The spectrum of the gas from clèveite, as worked out at fullest detail in this most thorough and painstaking manner, proved at first sight one of great irregularity, and had its discovery fallen some ten or a dozen years earlier, investigators would in all probability have been content to accept it as observed, and to enquire no further.

But we had advanced beyond this stage of spectroscopic work. Even in the infancy of spectrum analysis it was felt that there ought to be some close connection between the undulations indicated by the different lines of a glowing gas; that they must be related to each other by some unfelt rhythm. They seemed like the broken snatches of distant music borne to our ears by fitful gusts of wind; they were parts of a complete harmony to the knowledge of which we had not yet attained, but we were assured that if it could but reach us in its fulness each of these detached and separate vibrations would find its proper place, and show itself as an integral part of a beautiful and perfect whole.

It was with some kindred thought to this that in 1871 Prof. Johnstone Stoney, in a paper communicated to the Royal Irish Academy,* suggested that the three lines of hydrogen, now known as Hα, Hβ, and Hδ, and which give rise to the three Fraunhofer lines C, F, and *h*, were respectively the twentieth, twenty-seventh, and thirty-second harmonics of a fundamental vibration whose wave-length *in vacuo* was 0·13127714 of a millimètre. But the third line of hydrogen, Hγ,—"near G," or G′, as it is generally called,—had no place in this arrangement, and attempts to fit similar formulæ to other spectra ended only in disappointment.

At that time our knowledge of the hydrogen spectrum—which, as one of the simplest of all spectra, and as given by the lightest of gases, appeared specially marked out for this investigation—did not ascend beyond the violet. The "deep things out of darkness" which the unseen regions of the ultra-violet were to yield were not then disclosed. But when Dr. Huggins' photographs of stellar spectra* revealed the long series of lines in the ultra-violet in stars of the first type, it became an almost irresistible inference that these were the completion of the hydrogen spectrum. They made, with the four lines which we knew of old, a series so obviously rhythmical, so obviously one, that the conclusion could hardly be avoided.



A further and an important step forward was due to a study undertaken by Prof. Piazzi Smyth. Prof. Smyth was in the habit of drawing his spectra and expressing the positions of his lines on a scale of "wave-numbers to an inch," instead of, as usual, on a scale of wave-lengths; and in particular had made a fine map of the great green band of the beautiful spectrum of carbonic oxide. This map he submitted to the inspection of Prof. A. S. Herschel in November, 1883, who pointed out that the "wave-numbers" of these lines formed two perfectly similar arithmetical series, so placed with respect to each other that the fifth line of the first series was coincident with the first of the second. Further, the ninth line of the first series showed as a close doublet, and the tenth and following lines as doublets, each slightly wider than the preceding one.†

* *Proc. Roy. Irish Acad.*, Jan. 9th, 1871.

* *Phil. Trans.*, Vol. CLXXI., 1880, p. 669.
† *Trans. Roy. Soc. Edin.*, XXXII., 1884.

This discovery was closely followed by several similar ones. M. Cornu, early in 1884,* announced with regard to the three great bands of the solar spectrum, A, B, and D, that the telluric lines of the last named "form two unequal series of double lines, whose channelled appearance immediately recalls that of the telluric groups A and B;" that the three bands may be looked upon as forming three harmonic groups analogous to the triplets of magnesium and zinc; and that the reciprocals of the wave-lengths of the homologous lines of the three groups are very nearly in arithmetical progression. A year or so later Prof. Rowland commenced his study of the same bands, and not only confirmed Cornu's observation of their resemblance, but also found that the lines of each band showed an approximation to the same type of structure which Prof. A. Herschel had remarked in the green carbonic oxide band. But as the lines did not form a series rigidly harmonic within the limits of accuracy of his measurements, he did not publish his results.†

There is no occasion to review all the attempts which have been made to compel various spectra to give up the secret of their structure. The story of the first complete success in this field has already been told in the pages of Knowledge by the late Editor. ("On the Rhymical Group of Hydrogen Lines visible in many Stellar Spectra," by A. C. Ranyard, Knowledge, September, 1891.) Prof. Ames' verification of Balmer's law was followed very quickly by a most important announcement by Profs. H. Kayser and C. Runge with regard to the spectra of the alkalies. These various spectra were all formed, they reported, "in an entirely analogous manner, which is especially manifest if, instead of the wave-lengths, we consider the reciprocals—that is, the number of vibrations. Each spectrum is seen to be made up of several series of lines, each of which may be represented with great accuracy by the formula

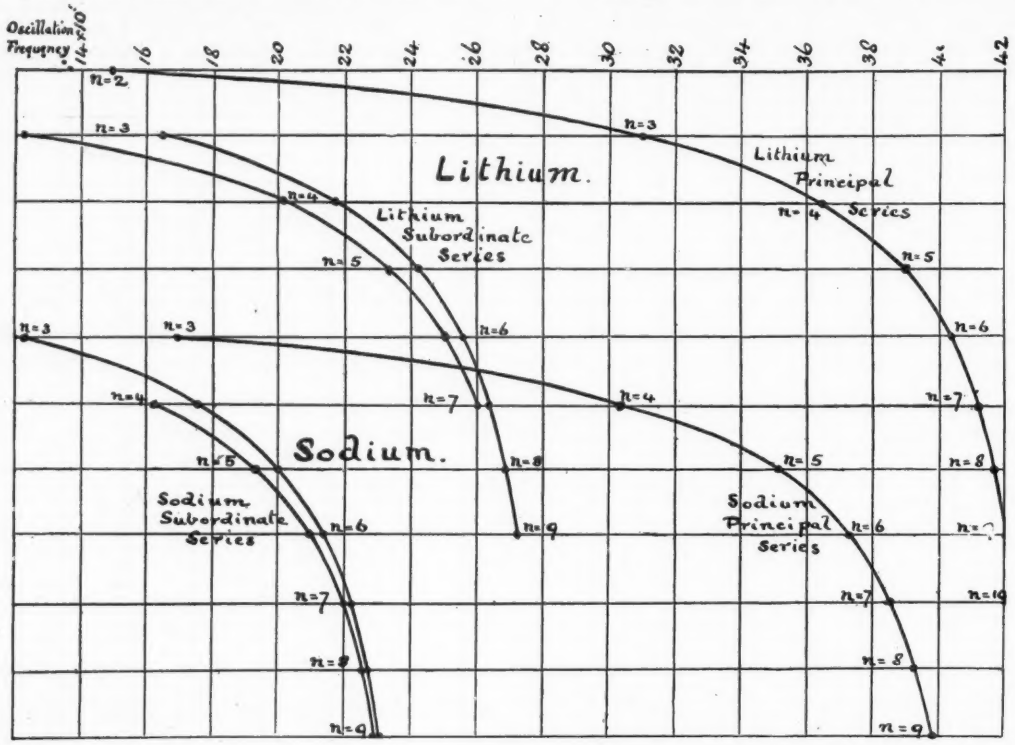
$$\frac{1}{\lambda} = A - \frac{B}{n^2} - \frac{C}{n^4}$$

where λ is the wave-length; A, B, and C are three constants; and n stands for the series of numbers from $n = 3$ upwards."*

It will at once be seen that Balmer's formula is only a special case of the above in which $C = 0$. And it will also be seen that as n increases, so $\frac{1}{\lambda}$ tends to approach A, which, accordingly, gives the value of the asymptote of the series. The constant B is *nearly* the same for all spectra, whilst the constant C gives the rate of convergence.

The spectra of the alkalies, however, exhibited other and more complicated relations than the spectrum of hydrogen. In each case three distinct series were noted. The principal series—the one giving the strongest lines, and those most easily reversed—is the one of longest stride and greatest extent; and for all the spectra but that of lithium it consists of doublets, the members of which continually approach each other as they approach the red end of the spectrum, the difference of the "wave-number" of the components of any pair being inversely proportional to n.

But besides the principal series of lines each spectrum contains other subordinate series. Lithium contains two. For both these the constant A as well as the constant B are nearly the same; in other words, they both approach



* *Comptes Rendus*, Vol. XCVIII., No. 4.

† Ames, *Phil. Mag.*, 1890, II., p. 41.

* *Sitz. d. Berliner Akad.*, June 5th, 1890. Profs. Kayser and Runge announced in 1888 that they had discovered the general law of spectra, but do not seem to have published it until 1890.

the same limit. The same is the case with sodium and potassium; but whilst the lines of lithium are single those of sodium and potassium are double, and the successive doublet intervals are always the same. We might therefore express the case a little differently by saying that sodium and potassium each give two pairs of subordinate series, and that the one series of each pair is displaced throughout as compared with its companion series by a constant oscillation-frequency.* And, further, this constant difference is the same as that shown by the two components of the first doublet of the principal series.

The accompanying diagrams will exhibit the character of these relations for the spectra of lithium and sodium better than much verbal explanation. In the first diagram the upper line for lithium and sodium shows the complete spectrum of the element; its analysis into principal and first and second subordinate series is shown below. The second diagram corresponds to that given by Mr. Ranyard for hydrogen in the paper referred to above, and is intended to show the convergence curves of the different series. In each case the scale adopted is one of oscillation-frequencies to the mètre. Doublets are shown throughout as single lines, the scale of the diagrams not permitting them to be shown as distinct pairs.†

* Prof. Hartley had shown that this relation held good for the triplets of magnesium, cadmium, and zinc as early as 1882 (*Journ. Chemical Society*, 1882 and 1883).

† The constants given for these spectra by Profs. Kayser and Runge are as follows (*Abh. der Kgl. Preuss. Akad. der Wissen., Berlin*, 1890):—

		A	B	C
Lithium—				
Principal Series		$4{\cdot}35193 \times 10^{6}$	$1{\cdot}12186 \times 10^{7}$	$9{\cdot}069 \times 10^{8}$
Subordinate „	I.	2·858674	1·096255	1·847
„ „	II.	2·866669	1·22391	231·700
Sodium—				
Principal Series		4·149634	1·27040	843·841
Subordinate „	I. *a.*	2·454912	1·20726	197·891
„ „	I. *b.*	2·456583	1·20715	197·935
„ „	II. *a.*	2·447534	1·10065	4·148
„ „	II. *b.*	2·449484	1·10153	3·487

The lines in the two spectra are as follows:—

Lithium.

Wave-lengths expressed in tenth-mètres.

n	Principal Series.	First Subordinate Series.	Second Subordinate Series.
2	6708·2	.....	.....
3	3232·77	6103·77	.....
4	2741·39	4602·37	4972·11
5	2562·60	4132·44	4273·44
6	2475·13	3915·2	3985·94
7	2425·55	3794·9	3838·3
8	2394·54	3718·9	.....
9	2373·9	3670·6	.....
10	2359·4	.....	.....

Oscillation-frequencies to the mètre.

2	1490713	.....	.....
3	3093322	1638332	.....
4	3647784	2172794	2011219
5	3902287	2419878	2340035
6	4040192	2554148	2508818
7	4122776	2635116	2605320
8	4176167	2688967	.....
9	4212479	2724350	.....
10	4238366	.....	.....

Profs. Kayser and Runge have more recently analysed the spectra of a large number of elements after the same manner in which they had treated those of lithium and sodium, but their results for these need not detain us now. But when Runge and Paschen followed up their careful elaboration of the spectrum of the clèveite gas by a similar analysis, a very striking circumstance was revealed. The clèveite lines gave, not one series like hydrogen, nor three like lithium, but six, and of these some were series of single lines, some of doublets.

"We have," the observers report,* "accordingly, here to do with six series, among which it twice happens that two series converge towards the same place. Two of these converging series, namely, those beginning at 7065 and at 5876, consist of double lines with equal differences of oscillation-frequencies. We associate these with the remaining one which has double lines, that which begins at 1·12 μ in the infra-red. Two at all events of the three other series have no double lines; they diverge from the same situation, and we unite them with the remaining series into a second system.

"Both the systems prove to have a similar appearance, and all the lines of the first system are stronger than the corresponding lines of the second system.

"Further, it appears that both these spectra are very similar to the spectra of the alkalies. . . . . We can distinguish in each of them two subordinate series diverging from the same situation, of which the brighter is the more closely spaced. Moreover, each system contains a principal series whose lines are stronger than

Prof. Snow has observed the line corresponding to $n=3$ of the second subordinate series.

In the following tables of the sodium lines only the first component of each doublet is given; but the difference between the two components is added, as this will render more clear the distinction between the doublets of the principal and of the subordinate series.

Sodium.

Wave-lengths expressed in tenth-mètres.

n	Principal Series.	First Subordinate Series.	Second Subordinate Series.
3	5896·16 ;—5·97	.....	8200·3 ;—12·0
4	3303·07 ;—0·60	6161·15 ;—6·53	5688·26 ;— 5·36
5	2852·91	5153·72 ;—4·53	4983·53 ;— 4·23
6	2680·46	4752·19 ;—3·83	4669·4 ;— 4·2
7	2593·98	4546·03 ;—3·28	4500 0 ;— 5·7
8	2543·85	4423·7 ;—3·5	4393·7 ;— 3·0
9	2512·23	4343·7	4390·7

Oscillation-frequencies to the mètre.

3	1696019 ; + 1719	.....	1219468 ; + 1787
4	3027487 ; + 550	1623074 ; + 1722	1758007 ; + 1658
5	3505193	1940346 ; + 1707	2006610 ; + 1704
6	3730703	2104293 ; + 1697	2141603 ; + 1928
7	3855080	2199721 ; + 1589	2222222 ; + 2819
8	3931049	2260551 ; + 1790	2275986 ; + 1555
9	3980527	2302185	2311765

M. Becquerel has observed the line corresponding to $n=3$ of the first subordinate series. A pair of lines, not included in the above table, is also seen at $\lambda = 5675\,92$;—5·52; oscillation-frequency, 1761829 ; + 1715. Dr. Johnstone Stoney, in an important paper on the "Analysis of the Spectrum of Sodium," read before the Royal Dublin Society, 1891, November 18th, claims this pair as corresponding to a negative value of $\frac{1}{\lambda}$.

* *Proc. Berlin Akad.*, June 20th, 1895. *Phil. Mag.*, Sept., 1895, p. 298.

those of the subordinate series, and which extends to shorter wave-lengths."

Elsewhere they write:*—"There is no instance of an element whose spectrum contains two pairs of series ending at the same place. This suggested to us the idea that the two pairs of series belonged to different elements. . . . . We therefore believe the gas in clèveite to consist of two, and not more than two constituents. We propose to call only one of the constituents helium—the one to which the bright yellow double line" (D_3) "belongs, whose spectrum altogether is the stronger one—while the other constituent ought to receive a new name."

A very suitable name has been accordingly proposed by Dr. Johnstone Stoney, and the second element in clèveite gas is now known as "parhelium." Further evidence that "helium" and "parhelium" are really two distinct elements must form the subject of another paper, in which it will also be possible to glance at their different astronomical relationships.

THE BIRCH.

By George Paxton.

"Most beautiful
Of forest trees, the Lady of the Woods."

WELL does the birch (*Betula alba*) deserve to be called "Queen of the Forest" and "Lady of the Woods." No tree is more generally admired on the ground of its own intrinsic beauty: the favourite of poet, painter, and all lovers of nature. It matters not whether it be seen in a London square, Highland glen, or Lowland pasture; the eye is at once arrested by its light and graceful elegance.

But perhaps all the beauties of a well-grown birch are best brought out when the tree happens to be of the weeping variety, growing beside and overhanging still water. Then note and admire its silvery stem, graceful drooping branches, and light fragrant foliage, perhaps lit up by the rays of the setting sun into festoons of pure gold; the water below reversing and doubling all! Thus seen, on a quiet autumn evening, the birch forms a picture that will linger in the memory—"a thing of beauty and a joy for ever."

With the poet Burns the birch, or birk, as he called it, was chief favourite among trees, being mentioned in his works no less than thirteen times. In the noblest and most pathetic of all his poems, "To Mary in Heaven," the place of last parting is described—

"O'erhung with wild woods thick'ning green;
The fragrant birch, and hawthorn hoar
Twin'd amorous round the raptur'd scene."

Again he goes to meet his "ain kind dearie"—

"Down by the burn, where scented birks
Wi' dew are hanging clear. . . ."

The birch is found in all the colder regions of Europe, Asia, and America. It is common in this country, and a true native of the British Isles. It is very abundant throughout the whole of Russia, and in Greenland it is said to be "the only tree;" but there it is much diminished in size, owing to the coldness of the climate. In Britain it grows to a height of about fifty feet, with a trunk seldom more than ten feet in girth. It is extremely hardy and a rapid grower (especially the weeping variety), but does not live to a very great age. One of the finest birches in Scotland is represented in Fig. 1. It is about seventy feet in height, with a girth of eleven feet four inches, and was planted about seventy years ago on the banks of "bonnie Doon."

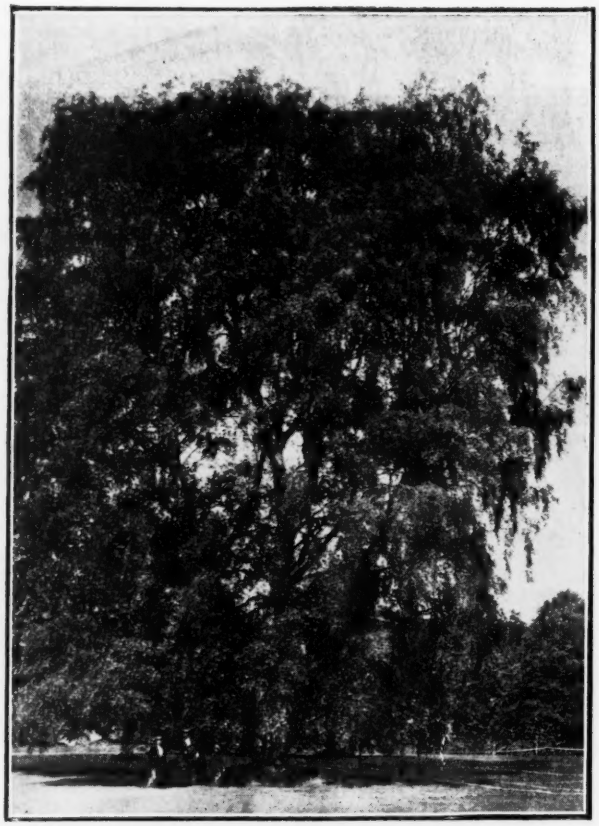


Fig. 1.—The Birch Tree near the "Auld Brig o' Doon."

The tree is known at first sight by its silvery bark, small leaves, and light and graceful form. The leaves are ovate, and unequally serrated. (Fig. 2.) The flowers, in the form of drooping catkins, appear in April and May.

The fragrance to which reference has been made comes from a kind of resin which exudes from the leaves and young twigs, especially after rain or heavy dew. The wood of the birch is tough, but not very durable. It is used for making spoons and shoes chiefly in Russia, and in France and Germany for carriage construction, especially for the felloes of the wheels; but its principal use is for gunpowder charcoal. The bark is remarkable for its durability; it is almost indestructible, and will remain quite fresh long after the wood it has encircled has rotted away. The ancient inhabitants of Britain took advantage of this peculiarity and built their canoes of birch-bark; remains of these canoes have been frequently dug up from the gravel banks of the River Clyde. In Canada, birch-bark canoes are still used; they are made from a species known as the canoe or paper birch. Portions of the smooth bark, ten to twelve feet long, are stripped from the tree, stitched together with fibre, and the seams coated with resin, thus making a very light boat.

* *Nature*, Sept. 26th, 1895.

It is said one calculated to hold four persons weighs only fifty pounds. An oil distilled from the bark is much used in Russia for tanning the finer kinds of leather; this oil not only preserves the leather and prevents it from getting mouldy, but also imparts that agreeable odour characteristic of Russia leather.

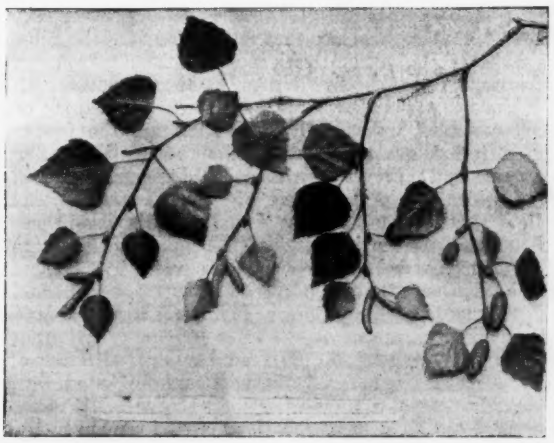


Fig. 2.—Leaves of Birch.

The sweet watery sap with which this tree abounds, and which will flow freely if a notch be made through the bark in spring, was formerly much valued for its supposed medicinal virtues; it was also fermented into a kind of beer or wine, which is still done in some parts of Sweden. The tree not only supplies beer and wine, but also tea, the young eaves being sometimes used in Finland for this purpose.

But the uses to which the birch has been put may be said to be almost too numerous to mention. According to Loudon, the Highlanders made *everything* of it:—"They build their houses, make their beds, chairs, tables, dishes, spoons, construct their mills, make their carts, ploughs, harrows, gates and fences, and even manufacture ropes of it. The branches are employed as fuel in the distillation of whiskey; the spray is used for smoking hams and herrings, for which last purpose it is preferred to every other kind of wood. The bark is used for tanning leather, and sometimes, when dried and twisted into a rope, for candles. The spray is used for thatching houses, and, when dried in summer with the leaves on, makes a good bed where heather is scarce." We suspect the absence of better wood had not a little to do with many of these uses.

The tree is most liable to a disease produced by a very minute gall-mite, which attacks the young buds and causes them to grow into a large mass of twigs like an old rook's nest; these are known as witch-knots or witches' brooms.

GREEK VASES.—II.*

A.—VASES OF THE PRIMITIVE PERIOD, TO 600 B.C.

By H. B. Walters, M.A., F.S.A.

In this article we shall trace the history of the ceramic art in Greece from its earliest beginnings down to the time when it may be said to have passed out of the primitive period, and to be beginning to take high rank as a decorative art. A rough limit of demarcation between this period and that discussed under the heading B is the introduction of mythological subjects, and, from a technical point of view, the adoption of certain processes for enhancing the effects of an otherwise simple style of decoration. It will be the purpose of this article to show how this development is attained.

The earliest vases that have been discovered on Greek soil are represented by the finds of Dr. Schliemann at Hissarlik, the supposed site of the ancient Troy. These vases are of a very rude type, and must belong to a very primitive civilization. The forms are very varied, but suggest rather experiments on the part of the potter than a fixed number of types, each for a different purpose. We note in the so-called "owl vases," which are roughly manufactured into the form of that bird, a first attempt to establish, in the analogy between a vase and a living thing, a principle of design and decoration (on which principle we speak of the "mouth," "body," "foot," etc., of a vase). The Hissarlik vases are hand-made, and fired to a dull black colour; they are never painted, but patterns are occasionally scratched upon them.

The products of the Island of Santorin (the ancient Thera) and of the neighbouring islands of the Archipelago are of a more developed kind. These vases have been found beneath a stratum of lava, the result of a great volcanic eruption, which, on geological evidence, is supposed to have taken place between 2000 and 1800 B.C.; and there is no doubt they were made from local clay. The most notable feature in this ware is that for the first time we have vases painted with vegetable patterns and figures of animals. This is in itself a very great and remarkable advance. The colours are applied with a brush, and two tones — a yellowish white and a brown — are employed.

Fig. 3.—Jug of Rhodian Style. From the Island of Thera.

The vases of Thera supply a natural point of transition to the second great stage of early art represented by the Mycenæan ware. Spread over virtually the whole of the ancient classical world there has been found a class of pottery more or less uniform in technique and ornamentation. In the first instance the discovery of vases of this class had been confined to the islands of the Ægean Sea, more especially Rhodes and Crete, and they had attracted comparatively little notice from archæologists. But the excavations of Dr. Schliemann on the Acropolis of Mycenæ from 1876 onwards, together with results obtained near Athens and from other parts of Greece proper, have brought about a great change in this respect. In the tombs of Mycenæ large quantities of vases have been found with the same characteristics as those previously found in the islands. The special interest which they have evoked is due to the fact that they are, with some show of probability,

* The first article appeared in the February number of Knowledge.

regarded as representing the age of Agamemnon and other legendary Greek heroes, the seat of whose power was at Mycenæ; and if this be so, it would place them in the twelfth and thirteenth centuries B.C.

This Mycenæan ware is probably Greek, but shows traces of Egyptian and Asiatic influence; moreover the subjects of the painted vases are largely drawn from marine objects, a point from which it may be inferred that they are the products of a seafaring people, which would also be implied by the remarkable number of different sites on which they have been found, all on or near the coast of the Mediterranean.

The Mycenæan vases are remarkable for the introduction of lustrous colours, a new factor in vase-painting, and to all intents peculiar to Greek ceramics. Hitherto the colours used were dull and opaque, or what is technically known as *matt;* now the pigments more resemble varnish from their thick and lustrous character. The painting is in all shades of yellow, brown, or black, on a polished warm yellow surface. The shapes are highly characteristic, especially a tall, graceful, two-handled goblet (*see* Fig. 2 in the February article), and a jar with spout and small mouth, over which a bow-shaped handle passes, so as to close it up; this latter form is known as a "false amphora," and it was probably used for oil. A third form is a large capacious owl on a high stem, with two or three side-handles.

On the tall goblets we almost invariably find a cuttle-fish depicted. Seaweed and shellfish are very common, especially on the Rhodian specimens; and the British Museum possesses a unique specimen with a nautilus, found in Egypt. The special feature of these subjects is, however, the extraordinary naturalism which prevails.

On the other hand, with the human figure this is not the case; it is true that such subjects seldom occur on the Mycenæan vases, but when they do it is with all the characteristics of archaic rudeness and simplicity. This is only in accordance with a universal principle in Greek vase-painting, by which the mastery is first obtained over vegetable forms, next in the rendering of the lower animals, and it is not till the perfect development of art that the human figure is represented with absolute accuracy.

Fig. 2.—Large Vase (*Lebes*) of Phaleron Style. From Athens.

It should be noted that much of the ornamentation of these vases is influenced by the conventional decoration of metal-work; this is especially the case with those found at Mycenæ itself, and it must be remembered that this was an art in which these people pre-eminently excelled; moreover, it is an influence that makes itself felt throughout the whole history of Greek ceramics.

We must now turn aside to consider the products of an island which plays a remarkable part in the history of Greek ceramics, namely, Cyprus. Although the fabrics of this island are to a great extent rather Phœnician than Greek, it is yet impossible to disregard them in the consideration of a history of Greek pottery. The earliest examples of pottery found in the island are the products of the indigenous Greek people before the Phœnicians invaded the island. The vases are covered with a vitreous slip and baked to a lustrous red, and are ornamented with patterns of lines incised with a knife. Other vases are made of fine grey clay, and ornamented with appliqué work, or moulded into all kinds of fancy shapes. No bronze objects have been found with these, but stone spindle-whorls and similar articles. Coming down to a somewhat later period, we have the tombs which belong to the Mycenæan age, and the beginning of the bronze age in Cyprus. The native pottery found in these tombs is often an imitation of the imported Mycenæan fabrics. Many genuine Mycenæan vases have also been found in these tombs, the "false amphora" described above being remarkably common, and a small class of unique interest, of which two examples have lately been excavated for the British Museum; these are large two-handled jars with figures of men and women in chariots, which hitherto have only been found in Cyprus—and, in fact, there are barely half a dozen in existence. The two aforesaid vases were found on the site of the ancient city of Curium, of which we have a record in a passage of the geographer Strabo, that it was founded by the Argives, *i.e.*, the people of Argos in Greece, which at that time was closely connected with the Mycenæan civilization.

The next event of importance in the history of Cyprus was the advent of the Phœnicians, from which time onwards there is a great change in the style of the pottery. The tombs of this period contain many vases with geometrical decoration, corresponding to a development in Greece proper which we shall shortly discuss; and in the subjects we see a very marked Assyrian and Egyptian influence. From the former are derived figures of strange monsters and fantastic deities, while from the latter come such motives as lotos-flowers and aquatic birds. (*See* Fig. 1 in the February article).

Returning now to the mainland of Greece, we find Athens for the first time coming to the front and laying the foundations of the great reputation which, in later times, left her mistress of the field in the production of ceramic masterpieces. The period we have to deal with is that

of the Geometric vases (or Dipylon, as they are sometimes called, from the fact that most of them were found near the old Athenian gate of that name). It is, of course, a retrograde step on the Mycenæan fabrics, as may be easily seen by a comparison of the drawing on the examples of each style.

The Geometrical vases fall into three easily-distinguished classes, showing a gradual development in range of subjects. In the first class the decoration is purely geometrical, consisting of such patterns as lozenge and chequer, spirals, the typical Greek mæander and key patterns, and rows of vandykes or wavy lines (Fig. 1). Simple as the scheme of ornamentation is, many of these vases are very effective. In the next stage, panels are introduced containing figures of horses, deer, and swans and other birds. Vases of this class are generally found in Bœotia. In the third class a remarkable advance is made, and scenes from daily life are introduced, such as funeral processions and sea-fights. The human figures are extremely rude and conventional, and the effect is much marred by the prevalent practice of filling up every available space by ornamentation of some kind. Early Greek painters had a strange horror of leaving any part of a vase undecorated. These vases are of great size, and were mostly found in the ancient Athenian burying ground, just outside the Dipylon gate; they had been placed on tombs as memorials. It is possible that these representations of the cult of the dead derived their origin from Egypt, where paintings of this kind were so universal; in any case they imply the possession by the artist of an unexpected power of conception, though the execution falls far short of it. The technique is very similar to that of the Mycenæ ware. The figures are generally painted in lustrous black on a prepared ground, varying from stone colour to deep red. The favourite shape is that of a large jar on a high stem, with two comparatively small side-handles.

The great expansion of Hellenic life in the seventh century B.C., by extended commerce and colonization, placed the Greeks in continuous and intimate relations with all their neighbours. The result of this, as far as vase-painting is concerned, is seen in the new impulse given to the art by Oriental influences. Egypt opened her ports for the first time to foreign ships under the twenty-sixth dynasty (660-530 B.C.), and also stocked her armies with foreign mercenaries; while the same period saw the foundation of Ionian settlements at Naucratis and other places in the Delta. Nor must we forget the various products of Phœnician and Lydian craftsmen with which extended commerce had rendered the Greeks familiar, and we shall see how great an influence the metal-work of the former, and the textile fabrics of the latter, had on the ceramic products of the succeeding period in Greece.

In a small class of vases known as the Phaleron style, because found at Phaleron near Athens, new features are introduced, especially in the employment and treatment of new animal types, based in design and grouping on Oriental models. The only features of the Geometric style retained are small fragments of ornament employed for filling the field of the vase. (Fig. 2.)

Even stronger was the influence at work in the islands of the Ægean Sea, especially in Melos and Rhodes. Although the Melian ware is later in development than the Rhodian, it must be taken first owing to its close connection with the Dipylon style. Only a very few of the Melian vases are in existence, but these are of unique importance. They possess many features hitherto unknown, and show a great advance in drawing and composition. The admixture of Oriental style and design is especially obvious, but the most remarkable advance is shown in the employment of a purple pigment, laid on the black in places in order to enhance the effect. This is the first instance of a technical method which prevails in a varying degree throughout the whole history of vase-painting.

In the Rhodian vases the tide of Orientalism swells into full flood. While, under its influence, the painter evolved an effective and beautiful system of ornamentation, the potter condensed the earlier multiplicity of forms to a few simple and elegant types, of which the most characteristic are the *oinochoë* and the *pinax* or circular plaque. (Figs. 3 and 4.) The influence of metal-work is shown not only in these forms, but also in schemes of decoration.

The influence of Assyrian and Lydian textile fabrics, again, gives the appearance of embroidery to the scheme of design on many vases as seen in the rows of animals

Fig. 1.—Jug (*Oinochoë*) of Geometric or Dipylon Style. From Athens.

placed in bands round the body, while the rosettes which are introduced to fill the field are another result of the same influence.

A new and characteristic development introduced by the Rhodian potters is the practice of combining silhouette with outline drawing, leaving parts of the figures in ground-colour with a black contour. Further, the red clay is frequently covered with a cream-white engobe or slip, which was found useful for indicating flesh-colour. The subjects are drawn almost entirely from the animal creation, especially goats and lions; later vases admit human figures and grotesque monsters such as the Sphinx. Among the latter, one vase stands out conspicuous as possessing a subject drawn from Greek legend, of which

we give an illustration in Fig. 4. The scene represented is a combat between Menelaos and Hector over the body of Euphorbos, and the figures are identified by the fact that their names are inscribed over them in early Greek letters. By this means we are enabled to give the approximate date of the vase as 600 B.C.; the lettering of the inscription is that of the alphabet in use at Argos at that time, but the style of the vase is undoubtedly Rhodian, and we may suppose that it was painted in Rhodes by an Argive artist. The subject is derived from an epic source, though it is not actually to be found in Homer.

Closely linked in many respects with the vases of Rhodian origin is a very interesting class which was first made known by the labours of the Egypt Exploration Fund at Naucratis, in the Egyptian Delta, in 1883-6. Pottery, mostly fragmentary, was found in layers of different dates, reaching from about 650 or 600 B.C. down to about 400, and including specimens of most classes of Greek vases during those periods. This variety is no doubt due to the cosmopolitan character of a town like Naucratis, where devotees from all parts would make their votive offerings

Fig. 4.—Plate (*Pinax*), with contest of Menelaos and Hector over the body of Euphorbos. From Cameiros, Rhodes.

to Apollo or Aphrodite. Most of the fragments that have been found bear dedications, incised after the firing, to either of those deities.

Among all these classes of pottery one is marked off as clearly a local fabric, and apparently dating from the earliest days of the city (650-550 B.C.); it may therefore be appropriately discussed here as belonging to the transition from period A to B. One fragment bears an inscription "to Aphrodite in Naucratis," which was evidently incised on the vase *before*, instead of after, the firing, which is a proof of its manufacture on the spot. The technique of this ware shows a great advance on that of Rhodes; the vases are covered with an opaque white engobe or slip, on which the designs are painted in colours. The same combination of outline and silhouette drawing which has been mentioned in connection with the Rhodian pottery obtains here also. New colours, however, are introduced—no doubt under the influence of the Egyptian wall-paintings, especially a light sienna and an umber red.

It has been advanced by some authorities that the practice of using a white ground for the decoration of vases, in the form of a thick creamy engobe or slip, may be traced to Naucratis for its origin; but seeing how universally this method of decoration has been employed in all fabrics, not only of later date but in those contemporaneous with the Naucratis ware, the question cannot as yet claim to be definitely decided.

In the next article we shall hope to trace the history of vase-painting during the sixth century B.C.

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

SUNSPOTS and faculæ show a marked decrease in number and size. Conveniently observable minima of Algol occur at 11h. 38m. P.M. on the **9th** and 8h. 28m. P.M. on the **12th.**

Mercury is in superior conjunction with the Sun on the **18th**, and will not be visible till the last week in April. On the **25th** he sets at 8h. 6m. P.M., or 55m. after the Sun, with a northern declination of 16° 48′ and an apparent diameter of 5¼″. On the **30th** he sets at 8h. 47m. after the Sun, with a northern declination of 20° 22′, and an apparent diameter of 5½″. While visible he passes from Aries into Taurus.

Venus is too close to the Sun to be observed, and Mars is, for the purposes of the amateur, invisible.

Jupiter is an evening star, and is still a very fine object. On the **1st** he sets at 3h. 27m. A.M., with a northern declination of 21° 2′, and an apparent equatorial diameter of 40·5″. On the **10th** he sets at 2h. 53m. A.M., with a northern declination of 20° 57′, and an apparent equatorial diameter of 39·5″. On the **20th** he sets at 2h. 16m. A.M., with a northern declination of 20° 48′, and an apparent equatorial diameter of 38·3″. On the **30th** he sets at 1h. 39m. A.M., with a northern declination of 20° 35′, and an apparent equatorial diameter of 37¼″. While visible he describes a short direct path in Cancer. The following phenomena of the satellites occur before midnight on the days named, while the planet is more than 8° above and the Sun 8° below the horizon:—On the **1st** a transit egress of the shadow of the second satellite at 9h. 36m. P.M.; a transit ingress of the first satellite at 10h. 31m. P.M., and of its shadow at 11h. 45m. P.M. On the **2nd** an occultation disappearance of the first satellite at 7h. 41m. P.M., an occultation disappearance of the third satellite at 11h. 6m. P.M., an eclipse reappearance of the first satellite at 11h. 13m. 14s. P.M. On the **3rd** a transit egress of the shadow of the first satellite at 8h. 34m. P.M. On the **4th** a transit ingress of the fourth satellite at 10h. 17m. P.M. On the **6th** a transit egress of the shadow of the third satellite at 9h. 52m. P.M. On the **8th** a transit ingress of the shadow of the second satellite at 9h. 17m. P.M., and a transit egress of the satellite itself at 9h. 43m. P.M. On the **9th** an occultation disappearance of the first satellite at 9h. 35m. P.M. On the **10th** a transit ingress of the shadow of the first satellite at 8h. 8m. P.M., a transit egress of the satellite itself at 9h. 12m. P.M., and of its shadow at 10h. 28m. P.M. On the **13th** an eclipse disappearance of the fourth satellite at 7h. 56m. 58s. P.M., a transit egress of the third satellite at 8h. 39m. P.M., a transit ingress of the shadow of the third satellite at 10h. 10m. P.M. On the **15th** a transit ingress of the second satellite at 9h. 28m. P.M.,

and a transit ingress of its shadow at 11h. 55m. P.M. On the **16th** an occultation disappearance of the first satellite at 11h. 29m. P.M. On the **17th** a transit ingress of the first satellite at 8h. 46m. P.M., an eclipse reappearance of the second satellite at 9h. 40m. 31s. P.M., a transit ingress of the shadow of the first satellite at 10h. 3m. P.M. On the **18th** an eclipse reappearance of the first satellite at 9h. 32m. 56s. P.M. On the **20th** a transit ingress of the third satellite at 8h. 59m. P.M. On the **21st** a transit egress of the fourth satellite at 8h. 35m. P.M. On the **24th** a transit ingress of the first satellite at 10h. 41m. P.M., and of its shadow at 11h. 58m. P.M. On the **25th** an eclipse reappearance of the first satellite at 11h. 28m. 25s. P.M. On the **26th** a transit egress of the shadow of the first satellite at 8h. 47m. P.M.

Saturn is an evening star, rising on the **1st** at 9h. 36m. P.M., or about three hours after sunset, with a southern declination of 14° 50′, and an apparent equatorial diameter of 9·7″ (the major axis of the ring system being 43½″ in diameter, and the minor 10¼″). On the **10th** he rises at 8h. 52m. P.M., with a southern declination of 14° 39′, and an apparent equatorial diameter of 17¼″ (the major axis of the ring system being 43½″ in diameter, and the minor 10½″). On the **20th** he rises at 8h. 15m. P.M., with a southern declination of 14° 27′, and an apparent equatorial diameter of 17½″. On the **30th** he rises at 7h. 31m. P.M., with a southern declination of 14° 14′, and an apparent equatorial diameter of 17¾″. Titan is at its greatest eastern elongation at 1h. A.M. on the **17th**, and Iapetus in inferior conjunction at 4h. A.M. on the **14th**. Saturn describes a short retrograde path through a barren portion of Libra.

Uranus is an evening star, with, unfortunately, great southern declination. On the **1st** he rises at 10h. 23m. P.M., with a southern declination of 18° 30′, and an apparent diameter of 3·8″. On the **30th** he rises at 8h. 18m. P.M., with a southern declination of 18° 15′. He describes a short retrograde path in Libra.

Neptune has practically left us for the season.

Shooting stars are fairly plentiful in April, the best marked shower being that of the Lyrids, with a radiant point in R.A. 18h. + 33°. The radiant point rises on the evenings of the **19th** and **20th**, when the maximum occurs at about 6h. 30m. P.M., and south at 4h. 8m. A.M.

The Moon enters her last quarter at 0h. 24m. A.M. on the **5th**; is new at 4h. 23m. A.M. on the **13th**; enters her first quarter at 10h. 47m. P.M. on the **20th**; and is full at 1h. 47m. P.M. on the **27th**. She is in apogee at 3h. A.M. on the **11th** (distance from the Earth, 252,500 miles), and in perigee at 9h. A.M. on the **26th** (distance from the Earth, 223,320 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 10th of each month.

Solutions of March Problems.

No. 1.—(J. T. Blakemore.)

Key-move.—1. Q to R8.

If 1. . . . K to B7, 2. Q to B3ch.
1. . . . K to Q7, 2. Kt to B2disch, etc.
1. . . . K to B5, 2. Q to B3ch, etc.

No. 2.—(C. D. Locock.)

1. P to B7, and mates next move.

Correct Solutions of *both* Problems received from Alpha, J. S. Orr, G. A. F. (Brentwood), Lionel Pfungst, W. Willby, E. W. Brook. Of No. 2 only, from G. G. Beazley, A. E. Whitehouse, W. M. A. E., W. F. H. Worsley-Benison, J. T. Blakemore, W. Willby, E. W. Brook, W. W. Strickland.

H. S. Brandreth.—Q to Q2 will not solve No. 2.

J. T. Blakemore.—Your problem was considered good and difficult, especially in the continuations after the key.

A Norseman.—Thanks; no time to examine this month.

W. W. Strickland.—Many thanks for the book, and your remarks on the Eight Queens Problem. Unfortunately I am unable to find your postcard on the subject. I hope to compare your theory with that of "A Norseman" before next month.

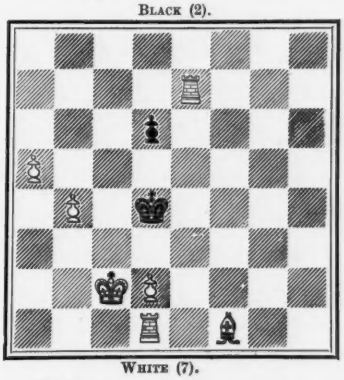
W. Willby.—The problem is a little too elementary considering the amount of force, the King's side pieces not being *necessary* to the problem. Could you not improve it greatly by removing the King's Rook and attendant Pawns, shifting the position towards the centre, and adding, if possible, one or two extra variations natural to the position?

The following curious problem is quoted from the *British Chess Magazine*. The curiosity lies in the fact that the solver who perceives the "idea" correctly will at first be convinced that there is no possible key:—

PROBLEM.

By C. A. Kennard.

Black (2).



White (7).

White mates in three moves.

The following game was the first to be concluded in the Anglo-American Cable Match on March 13th. The notes are quoted from the *Daily News*.

"Giuoco Piano."

White. (E. M. Jackson, London.)	Black. (D. G. Baird, U.S.A.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to QB3
3. B to B4	3. B to B4
4. P to Q3	4. P to Q3
5. P to B3	5. Kt to B3
6. B to K3	6. B to Kt3 (*a*)
7. QKt to Q2	7. Castles
8. Kt to B1	8. P to KR3 (*b*)
9. Q to K2	9. R to K1
10. Castles (*c*)	10. Kt to QR4
11. P to KR3	11. Kt×B

12. P×Kt	12. Q to K2
13. P to KKt4	13. Kt to R2
14. Kt to Kt3	14. B to K3 (*d*)
15. Kt to B5	15. B×Kt
16. KtP×B	16. B×B
17. Q×B	17. P to QKt3 (*e*)
18. QR to Kt1	18. K to R1
19. P to KR4	19. R to KKt1 (*f*)
20. P to R5	20. Q to B1
21. Kt to R4	21. R to Kt1
22. R to Kt6 (*g*)	22. Q to B1 (*h*)
23. R to Kt2	23. Q to Q1
24. Kt to Kt6ch (*i*)	24. P×Kt
25. RP×P	25. Q to K2 (*k*)
26. P×Kt	26. KR to KB1 (*l*)
27. R (R1) to Kt1	27. R toB2 (*m*)
28. R to Kt6	28. QR to KB1 (*n*)
29. Q to Kt3	29. P to QR3 (*o*)
30. P to B6	30. R× P
31. R×KtP	31. R(B1) to B2
32. R to Kt8ch.	32. K×P
33. R to R8ch.	33. Resigns

Notes.

(*a*) B takes B is best.

(*b*) A weakening move. P to Q4 is better.

(*c*) The only way to get any advantage out of the Giuoco Piano is to Castle rapidly on the Queen's side, and follow up with a King's side attack.

(*d*) Further waste of time. Black should have anticipated the King's side attack with such moves as B takes B, followed by Kt to Kt4.

(*e*) Black does not make the best of a bad position. If he wanted a counter-attack he should have played P to QKt4, followed by P to QR3, obtaining open files for his Rooks. The next move is meaningless.

(*f*) R to KKt1 seldom turns out well; it cramps the King too much.

(*g*) White makes the most of his opportunities, and deserves great credit for his spirited play. R to Kt2 would have served here equally well.

(*h*) If Kt to Kt4, P to B6 follows. Q to Q1 was a better move than Q to B1.

(*i*) White obviously had this move in contemplation for some time; it clears the way for the better operation of his Rooks.

(*k*) Obviously if Knight play away, R takes Pch follows.

(*l*) If K takes P, 27. R to Kt6, Q to B1 (as White threatened mate by R takes Pch), 28. P to B6 wins.

(*m*) K takes P was not quite hopeless.

(*n*) K takes P was a better move. For if then 29. R to R1, Q to B1; or if 29. P to B6, R takes P, giving up the Queen for two Rooks.

(*o*) Now he is hopeless and helpless. For if he plays K takes P, P to B6, P takes P, R takes Pch, and mates next move.

NOTICE.

A correspondent residing in London is desirous of playing one or two games by correspondence with a strong player. We shall be happy to forward him the address of any of our readers who may be willing to oppose him.

CHESS INTELLIGENCE.

On March 13th and 14th a match was played by Atlantic cable between selected teams representing the British Isles and the United States respectively. The contest was for a valuable silver trophy presented by Sir G. Newnes, Bart. Considerable care was taken in the selection of the British team, a tournament being held previously in order to decide one or two of the doubtful places. In this tournament Messrs. E. O. Jones and E. M. Jackson came out equal first, and failed to secure any decisive result in playing off the tie.

Mr. Jones was eventually chosen, but owing to ill-health his place was finally filled by Mr. Jackson, who by his brilliant victory quite justified his inclusion.

The British team played at the Cannon Street Hotel, the hours of play being from 3 to 7 and from 8 to 11.30 each day. At the end of the first day's play all the games were adjourned, the positions on the whole being in favour of Great Britain. On the following day the unexpected happened: Mr. Bird overlooked a simple mate in two moves, Mr. Mills unwisely consented to draw a game in which he had winning chances, and Mr. Tinsley was outplayed in an even ending and finally lost. This was the last game to be finished.

The following is the score :—

United States.			British Isles.
1. H. N. Pillsbury.	0	*v.*	J. H. Blackburne 1
2. J. W. Showalter	1	*v.*	A. Burn . . . 0
3. C. F. Burille .	1	*v.*	H. E. Bird . . 0
4. J. F. Barry . .	1	*v.*	S. Tinsley . . 0
5. E. Hymes . .	½	*v.*	C. D. Locock . ½
6. A. B. Hodges .	½	*v.*	D. Y. Mills . . ½
7. E. Delmar . .	½	*v.*	H. E. Atkins . ½
8. D. G. Baird . .	0	*v.*	E. M. Jackson . 1
	4½		3½

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Map and Two Plates.—1, Map of the Transvaal, showing Physical Features and Mineral Resources. 2, Photograph of "Crab" Nebula, Messier 1 Tauri. 3, Woodcock on its Nest amongst the Fallen Leaves.

NOTICES.

The numbers of Knowledge for January and February of 1894 can now be had, price One Shilling each.

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